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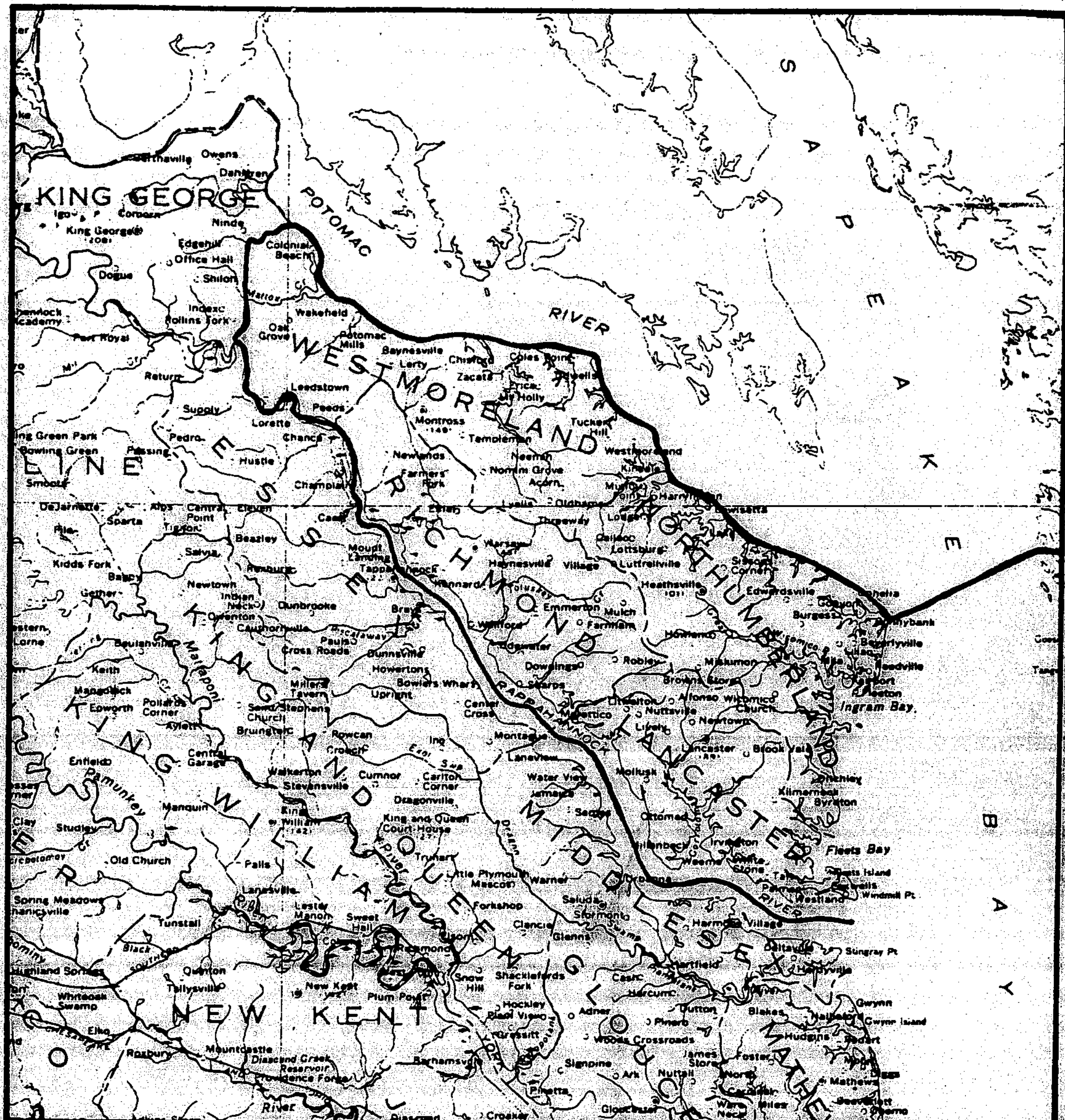
GROUNDWATER OF THE NORTHERN NECK PENINSULA, VIRGINIA



by
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and
Tidewater Regional Office

COMMONWEALTH OF VIRGINIA
STATE WATER CONTROL BOARD
BUREAU OF WATER CONTROL MANAGEMENT

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF PLATES

TABLE OF CONTENTS (Continued)

LIST OF TABLES

ACKNOWLEDGEMENTS

The Tidewater Regional Office of the State Water Control Board would like to express gratitude to the citizens of Lancaster, Northumberland, Richmond, and Westmoreland Counties who furnished information on their wells and who permitted water quality samples to be taken from them. Douglas and Dickinson Drilling Company, the Virginia Division of Mineral Resources and the United States Geological Survey supplied valuable information on well construction characteristics and hydrologic data.

This report was prepared by V. P. Newton, Geologist with the Tidewater Regional Office, with the able assistance of E. A. Siudyla, Senior Geologist of the Tidewater Regional Office, as well as, D. W. Hawthorn, Technician.

Executive Summary

The purpose of this report is to consolidate all currently available data regarding the groundwater conditions of the Northern Neck Peninsula of Virginia. The Northern Neck, which includes the counties of Lancaster, Northumberland, Richmond and Westmoreland, depends entirely upon groundwater as their only developed source for both industrial and potable water supply. The total groundwater withdrawals approximate two million gallons per day (2 mgd or 7.6 X 10^6 L/day) and demand is divided nearly evenly between domestic and industrial uses.

Geologic factors closely control the occurrence, distribution and quality of groundwater. In the Northern Neck, the geology is dominated by the Coastal Plain sediments which may be as thick as 3,500 feet (Plate 2). Within this thickness are the three major aquifer systems in which the groundwater supply of the Northern Neck occurs: the Water Table system, the Upper Artesian aquifer system and the Principal Artesian aquifer system.

Very little data exists concerning the Water Table aquifer system which provides many private dwellings with potable water. Due to seasonal level fluctuations it is not a totally reliable source.

The Upper Artesian aquifer system has a fairly consistent thickness of about 60 feet and varies from 200 feet below sea level in the western portions of the Study Area to 375 feet below sea level in the eastern portions (Plate 5). It has a low to moderate well yield potential (20 gpm (75.7 L/min) to 110 gpm (416.4 L/min)) and produces water of a moderately soft type.

The Principal Artesian aquifer system has a relatively large well yield potential (40 gpm (151.4 L/min) to 340 gpm (3179.4 L/min)), and varies from 300 feet below sea level in the western third of the Study Area to nearly 600 feet below sea level in Lancaster County (Plate 4). The water is generally of a soft sodium bicarbonate type. In the southeasternmost tip of Northumberland County the chloride values are slightly higher than normal (Plate 12 and Table 7). The sodium content of the groundwater in the eastern zone of the Principal Artesian aquifer system has been found to be greater than 200 ppm. This high sodium content in drinking water is considered detrimental when used on a daily routine basis by those people on a moderately restricted sodium diet. The characteristic of a high ratio of total dissolved solids to hardness in this aquifer is in contrast to a lower ratio for the same parameters in the Upper Artesian aquifer.

Although approximately 88% of the total groundwater withdrawals in the Northern Neck are from the Principal Artesian aquifer system, it has not thus far been noticeably overdeveloped. The needs of the area through the year 2020 under current and projected rates of utilization should adequately be met when considering the large potential for groundwater development. In order to obtain more specific knowledge of the

groundwater conditions a much more comprehensive and quantitative data base is needed throughout the Northern Neck peninsula. The most efficient method of obtaining this data is through the use of scientifically constructed research stations. Several stations are recommended to be constructed in the future.

CHAPTER I

INTRODUCTION

General Location and Background

The counties of Lancaster, Northumberland, Richmond and Westmoreland form the northern-most peninsula (Plate 1) of the Commonwealth of Virginia and as such collectively are called the Northern Neck of Virginia. The region's extensive coastal areas contrast slightly with the gently rolling inland hillsides to form a very rural setting.

The population of the Northern Neck Area exhibited only slight growth during the 1950's and the 1960's, as can be seen in Table 1 (below). The increase from 35,000 in 1950 to 37,000 in 1970 indicates only a 0.5% annual rate of increase. The largest town in the area is Colonial Beach, having a 1973 population of 2,244 (Department of Commerce estimate).

TABLE 1

POPULATIONS

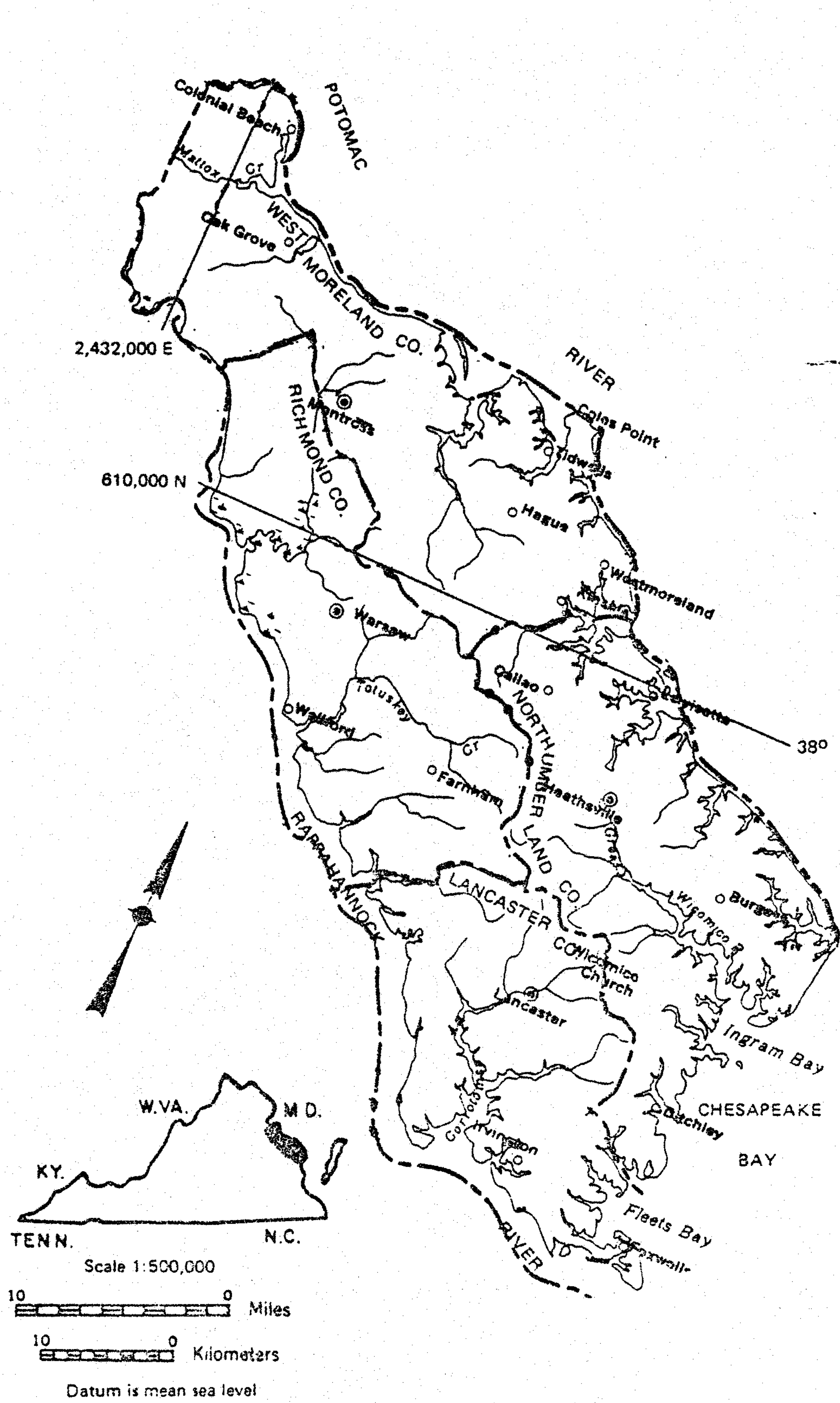
Counties	1950	1960	1970
Lancaster	8,640	9,124	9,126
Northumberland	10,012	10,185	9,239
Richmond	6,189	6,375	6,504
Westmoreland	10,148	11,042	12,142
TOTAL	34,989	36,776	37,011

Source: Division of State Planning and Community Affairs

Manufacturing is the most important of the area's industries. The seafood industry accounted for 23% of total employment in March, 1966. Other basic industries include agriculture, fisheries, the tourist trade and the non-local portion of wholesale trade. Approximately 4% of the total population were employed in agricultural jobs in the four-county area in March, 1966. The major source of farm income in each of the four counties is field crops, primarily soybeans, corn and small grains.

In the Northern Neck, groundwater is the only developed source of water to meet both industrial and potable water demands. Groundwater provides for much of the irrigational needs as well. Total withdrawals from the Northern Neck area approximate two million gallons per day (2 MGD (7.57×10^7 L/day)). This amount is split fairly evenly between domestic and industrial uses (see Chapter VI).

GENERAL LOCATION MAP



Source: Virginia State Water Control Board

Plate 1

Purpose and Scope

By consolidating available data regarding the groundwater conditions of the Northern Neck, this report should provide basic information useful to lay and professionally oriented readers. It is anticipated that this report will graphically delineate the available groundwater resources of the area. Since groundwater is the principal source of potable water in the area, this report will be useful in formulating future development plans. Considering land area, amount of construction, and overall expense, development of groundwater is generally much more economical than development of surface water. It is also easily adaptable to growth as new wells can be drilled when and, usually, where needed (see Chapter VI).

Methods of Investigation

The occurrence, availability, and quality of groundwater are governed by geology. Much of this report regarding the general background and geologic information was derived from previous reports, both published and unpublished. Some of the information on water-well construction and groundwater quality was obtained from other agencies, although the majority of it has been collected by the State Water Control Board (SWCB). Static water level measurements, for example, were obtained from both SWCB observation wells and wells owned by various entities (i.e., private, industrial, and agricultural). Driller's notes and logs were obtained from the files of area drillers. Pumpage reports and groundwater use surveys submitted to the SWCB were also utilized within this report. Water quality data from wells were used to determine chemical distribution within the major aquifers. The most recent of this quality information was obtained by the SWCB staff.

Previous Investigations

Few investigations have been made specifically of the groundwater resources of the Northern Neck of Virginia. Allen Sinnott, in 1969, drafted "Groundwater Resources of the Northern Neck Peninsula, Virginia" but it has not been published. Associated Engineers and Surveyors, Ltd., in 1975, prepared an evaluation of the groundwater resources of Westmoreland County. The most recent report was prepared by Lichtler, in 1975, titled, "Report on the Development of a Groundwater Supply at George Washington Birthplace National Monument". This groundwater system is located in northern Westmoreland County.

The earliest discussion of the groundwater resources of the entire Coastal Plain of Virginia included a county-by-county description of the groundwater (Sanford, 1913). Cederstrom (1943, 1946) published two bulletins regarding the groundwater quality in the Coastal Plain of Virginia. In 1953, the state of Maryland published H. F. Ferguson's investigation of the groundwater resources of nearby St. Mary's County. Brown, et. al.,(1973) studied the structural geology, stratigraphy, and relative permeability of strata in the North Atlantic Coastal Plain. Teifke and Onuschak (1973) presented the results of investigations of the stratigraphy, paleogeology and environmental geology of the Coastal Plain of Virginia.

Water Well Number System

The State Water Control Board's Bureau of Water Control Management maintains such water well information as well size and depth, yield, and other pertinent data in a computerized system at the Board's Headquarters in Richmond. Also, information on water quality and water level changes is maintained in Richmond by the Board~~'s Bur~~eau of Surveillance and Field Studies. Retrieval of this information for specific wells is possible by utilizing the water well numbering system.

This system is comprised of two numbers: the first one is a county identity number (Lancaster County is 151) and the second number is a sequential listing of wells in the County. For example, well number 151-58 refers to a specific well in Lancaster County. At the time of this report over 286 wells were identified and on file for this area. It is estimated that the total number of wells available for inclusion in this data system is substantially higher than the existing 286 wells.

CHAPTER II

PHYSICAL SETTING

Study Area Description

The Northern Neck Peninsula, encompassing 829 square miles, is approximately 65 miles long, with an average width of about 20 miles. Summarized in Table 2 (below) are the land and water areas. The area lies entirely within the Coastal Plain Physiographic Province. It is bounded by the Potomac River on the northeast, the Rappahannock River on the southwest, King George County on the northwest and the Chesapeake Bay on the east. Portions of three major river basins, the Rappahannock, the Potomac and the Small Coastal River Ba~~sins~~ are found within the Northern Neck.

TABLE 2

LAND AND WATER AREAS

County	Land Area Sq. Miles	Sq. Km.	Water Area Sq. Miles	Sq. Km.
Lancaster	136.5	353.5	16.5	42.7
Northumberland	190.1	492.4	32.9	85.2
Richmond	191.4	495.7	11.6	30.0
Westmoreland	236.0	611.2	14.0	36.3
	754.0	1952.8	75.0	194.2

Physiography

The Coastal Plain Physiographic Province in the Northern Neck is characterized by the following geomorphic (land form) features:

1) Broad, gently dipping terraces formed by changing ancestral sea levels.

2) Steep, ancestral, beach-ridge escarpments separating the terraces. (Two noted Tidewater scarps are the Surry Scarp which passes through Burgess and along the Eastern Branch of the Corrotoman River (75 feet above mean sea level, msl) and the Suffolk Scarp which passes through Kilmarnock and White Stone (50 feet above msl)).

3) Broad flood-plains characterized by meander loops and depositional features. (This type of stream morphology is characterized by the stream expending most of its energy in lateral erosion rather than vertical downcutting, i.e. the upper Rappahannock River.)

4) The formation of fluvial-estuarine systems (drowned river valleys) occurred as river flood plains and channels were engulfed by a rise in sea level. (The lower Rappahannock and Potomac Rivers are examples of such found within the Study Area.)

Average relief of the Study Area is approximately 75 feet (23 km.) above msl.

Climate

The climate of the Northern Neck can be classified as temperate, with the annual, average temperature being 58°F (14°C). Latitude, topography, prevailing winds and proximity to the Chesapeake Bay and the Atlantic Ocean exert influence upon the climate of the area. Average annual precipitation in the area varies only slightly from a low of 40 inches (102 cm) in Westmoreland County to a high of 43 inches (109 cm) in Lancaster and Northumberland Counties.

The prevailing wind is from the southwest, which generally brings the moist air from the Gulf of Mexico to the area. Polar air masses from the northwest clash with the warm gulf air to produce most of the climatological changes that occur in the area.

Hydrology

The Northern Neck has many streams as well as several large tidal-river, bay areas. The massive, bay areas are surrounded by large areas of relatively flat and gently sloping terrain. The vast tidal-water resources of the Northern Neck are accompanied by many excellent natural wildlife habitats, found in the marshy lowlands in, and adjacent to, the tidal-stream estuaries. The land areas adjacent to the wetlands generally have a high water table which restricts suitability for septic tanks and drainfields.

The greater part of inland Northern Neck is webbed with valleys and ridges draining to many streams in the area. Generally, there are large, fertile plateaus of gently rolling land between the stream watersheds. These plateaus are suited ideally to the farming operations for which they are primarily used. Many of the stream valleys have slopes on the order of ten percent or greater, and most of them have slopes exceeding five percent.

Soils

The soils of the four-county area have been divided into three major groups: the upland soils, the low-marine, terrace soils, and the piedmont river soils. On the higher terrace, the soils are generally well drained, while those of the level areas have impeded drainage. Generally, the soil conditions in all four counties are quite good, both for building and for septic tanks. In the low, marshy lands and along low shorelines the soil conditions are unfavorable for sewage percolation. The higher ground along the major highways, away from the shore, is almost all favorable for structural building, as well as suited for the use of septic tanks and drainfields.

Northumberland and Lancaster Counties are the only counties in the Study Area which have a completed soil survey. This survey was prepared by the U. S. Department of Agriculture, Soil Conservation Service (USDA, SCS) in cooperation with the Virginia Agricultural Experiment Station. The soils delineated in that survey are typical of those found in the low lying coastal areas of the other counties.

General soil maps for each of the four counties in the Study Aaea have been prepared by the USDA, SCS. The general groupings of soil, or associations, contain a few major soils and several minor soil types in a pattern that is characteristic, but not uniform, for the area. As a result, detailed site investigation is necessary to determine the suitability of specific sites for a particular land use.

Existing Patterns of Land Use

The two major uses of land within the area are for farming and forestry. These two land practices exemplify the rural-agricultural economy that historically has dominated this area. In addition to stands of commercial and non-commercial pine and hardwood forests, cultivated vegetation includes soybeans, corn, wheat, and tobacco. The protection of the hillside areas is important from a water-conservation standpoint since the forest cover helps retain a large percentage of rainfall for recharge of groundwater supplies.

Towns and older, small communities generally are located in the upland-plateau areas. There has been very little development in the hillside areas. Urban growth and its effects have not been very significant to date; however, recent developments around towns, along major highways and near shorelines indicate that urban growth may become more evident in the future.

CHAPTER III

HYDROGEOLOGY

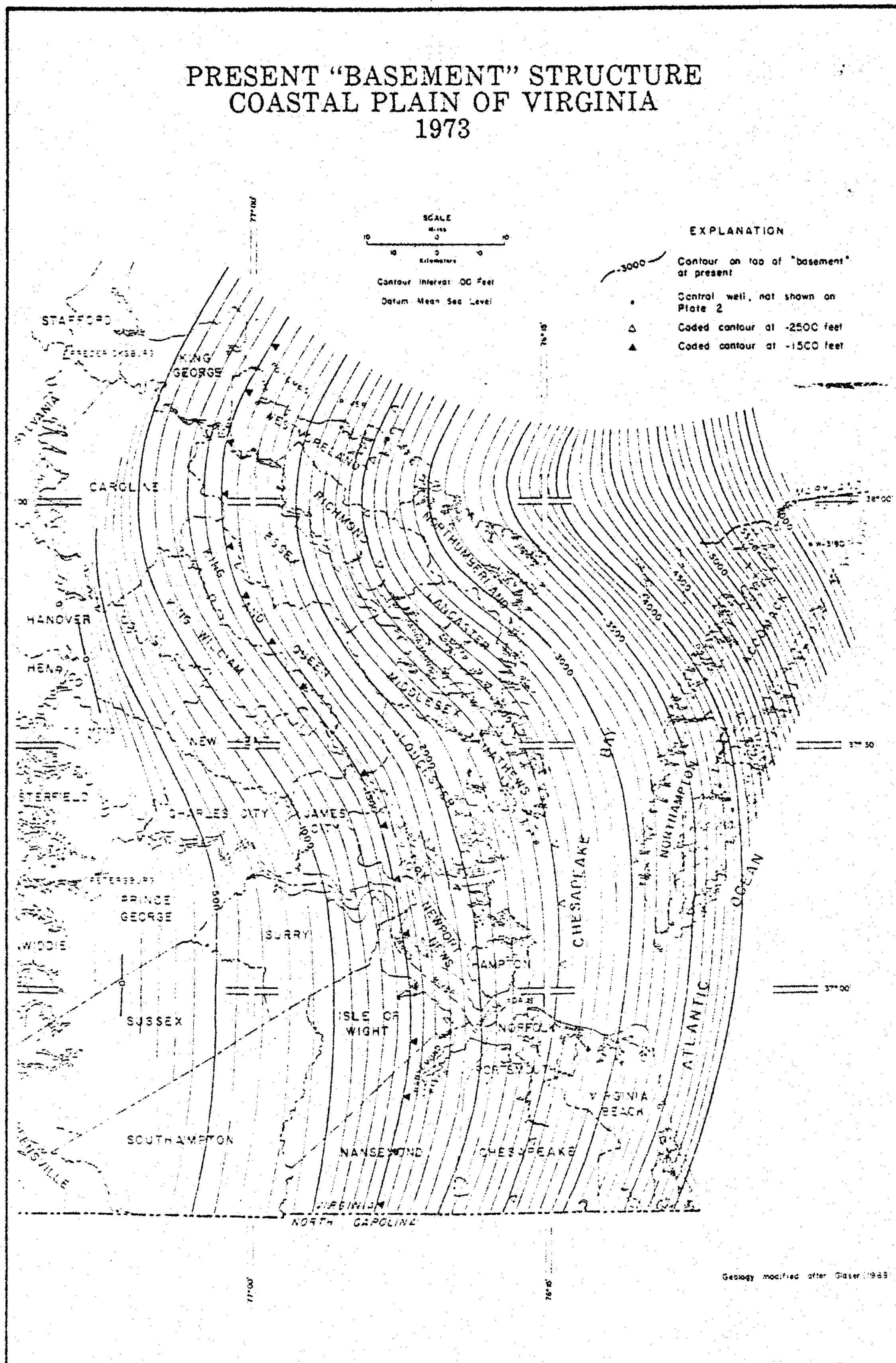
Geologic Setting

Geologic factors closely control the occurrence, distribution and quality of groundwater. The most important of these related factors in the Coastal Plain is the lithology or types of rocks. The ability of different types of rocks and sediments to absorb, store and transmit water varies greatly according to their make-up. Sediments which act as a reservoir and allow the favorable transmission of water are referred to as aquifers, while those that are neither porous nor permeable enough to yield water are termed aquicludes. As water moves underground it acquires a chemical constituency which is uniquely characteristic of the type of sediment in which it circulates.

The Northern Neck sediments, as part of the Coastal Plain Province, consists of a seaward-thickening and gently dipping wedge of sands, silts, clays and marls deposited by fluvial, deltaic and marine processes, overlying a pre-Cretaceous basement complex. For a more detailed discussion of the geology of the entire Virginia Coastal Plain, see Cederstrom (1946), Brown (1972) or Teifke (1973).

Historic Sketch. The type of sediments deposited at a given place and stratigraphic position within the Coastal Plain Province are very much determined by its relationship to the coastline and rivers of the past and present. In the recent geologic past the shoreline has shifted back and forth several times, from as far west as near the present fall zone to east of the present beach line.

Uplift in areas west of the fall zone, 430-280 million years ago (Paleozoic Era), with coastal movements along the Atlantic Continental margin, have produced a seaward slope on the crystalline basement rock surface (Plate 2). Subsequent erosion of those uplifted areas filled the depositional basins to the east. These unconsolidated sediments are of Cretaceous (about 63-136 million years old), Paleocene (about 58-63 million years old), Eocene (about 36-58 million years old), Miocene (about 13-25 million years old), and Post-Miocene Ages (recent to about 13 million years old) (Table 3) and consist of alternating marine and non-marine, depositional strata. In the eastern extreme of the Study Area, the thickness of these sediments reaches approximately 3,500 feet. To the west, the fall zone itself is actually the area of outcrop of the basement complex, and the overlying, unconsolidated sediments decrease in thickness to zero feet. The formational boundaries presented in this report are based mainly on lithostratigraphic correlations, interpretations of geophysical logs, and previous publications.



Source COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES

Plate 2

Stratigraphic Units

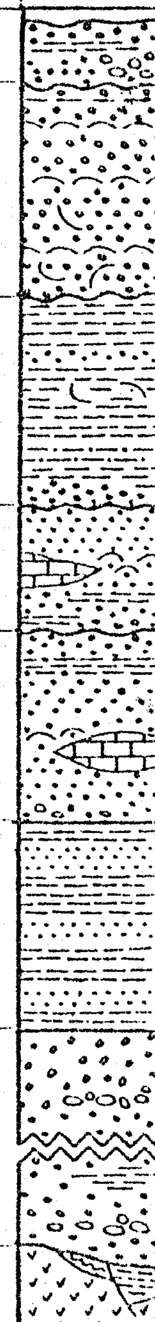
	AGE	RICHARDS (1967)	PRESENT REPORT	Lithology	CHARACTER	AQUIFER UTILIZATION
Quaternary	Pliocene-Holocene		Columbia Group		Light-colored oxidized silts, sands and gravels	Many shallow wells for domestic supplies
Tertiary	Miocene	Yorktown Formation St. Marys Formation Choptank Formation	Yorktown Formation		Gray to bluish-gray silts, sands, shell beds	Some small supplies but little importance as a groundwater source
		Calvert Formation Chickahominy and Piney Point fms.	Calvert Formation		Drab greenish-brown clays and silty clays, commonly consolidated; plant fragments and mollusks. Coarse sand at base.	Basal sand tapped for a number of small supplies; moderately soft, low chlorides
	Eocene	Nanjemoy Formation	Nanjemoy Formation		Quartz-glauconite sands; shell beds.	Slightly developed
		Aquia Formation	Mattaponi Formation		Drab green, gray and brown glauconite-bearing clays; glauconite and quartz-glauconite sands.	Ample future and present supplies; 50-400 gpm; moderately mineralized, soft sodium bicarbonate
?	Paleocene ? ? Upper (?)	Mattaponi Formation				
Cretaceous	Lower	Raritan Formation Patapsco Formation Arundel Formation	"transitional beds"		Bright variegated fine-grained clastics; mainly nonfossiliferous. Finer and less feldspathic than Patuxent.	A source of supply in Southeastern Virginia not utilized in Northern Neck. Is tapped in Maryland.
		Patuxent Formation	Patuxent Formation		Mainly medium to very coarse grained sands and fine grained gravels Pale beds with light-colored clay inter-beds	Major source of supply in Southeastern Virginia. Not tapped in Northern Neck.
	Precambrian-Triassic		"basement"		Igneous and metamorphic rocks.	No test or production wells in Northern Neck

Table 3

Source: Teifke, Division of Mineral Resources (1973)

HYDROLOGIC AND LITHOLOGIC FENCE DIAGRAM

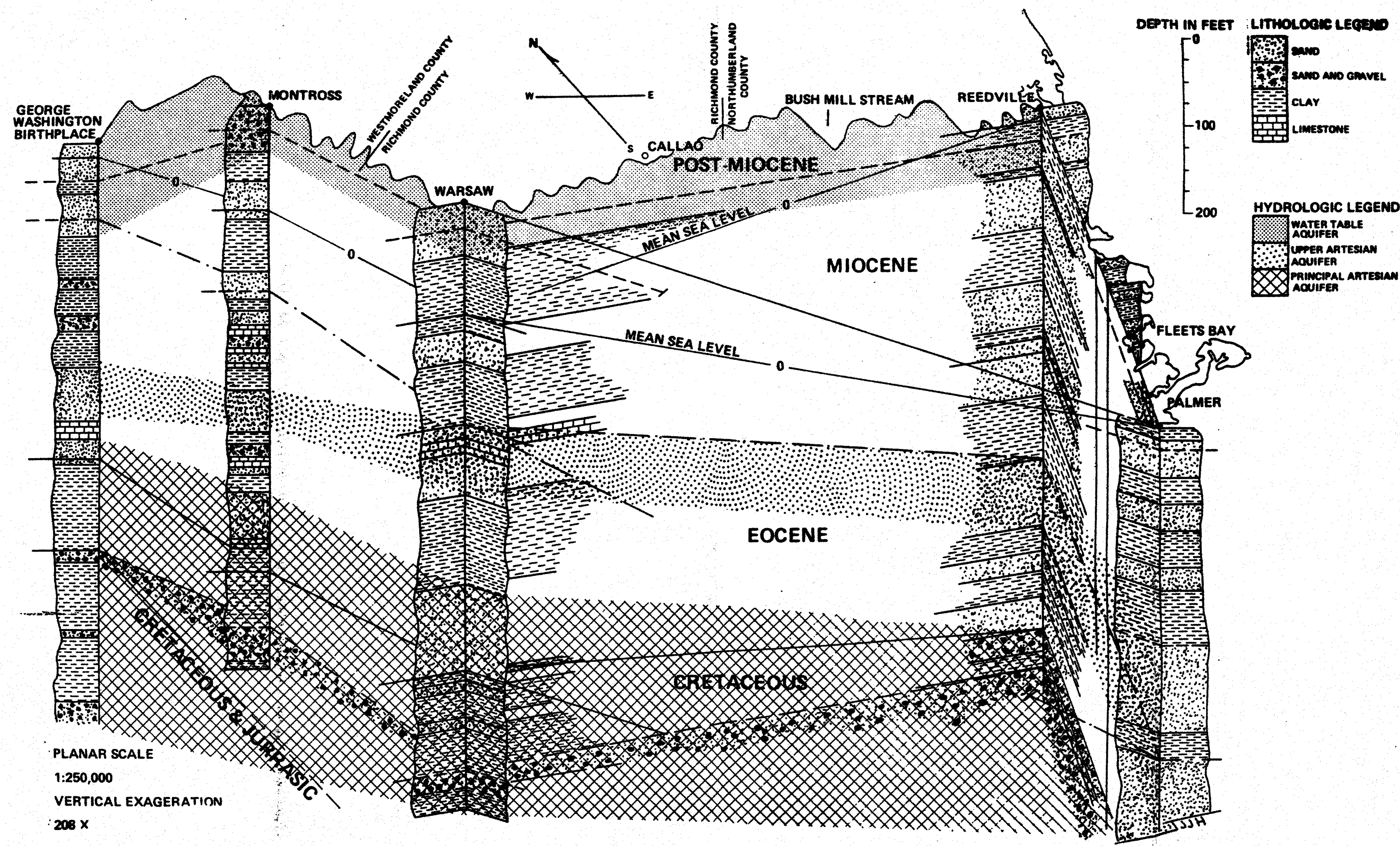


PLATE 3

Stratigraphy. In the Coastal Plain, the Precambrian-Triassic age "basement complex" underlies unconsolidated sediments of Cretaceous through Recent age (Table 3). The top of the "basement" dips almost due east from an altitude of -1400 feet (mean sea level) in the western tip of Westmoreland County to -3500 (msl) feet in the northeastern tip of Northumberland County (Plate 2) (Teifke, 1973). The basement is primarily granite or its saprolite (weathered residual) and is assumed to be equated with the Petersburg Granite exposed to the west in the Piedmont Province. "Redbeds", usually sandstone of Triassic age, are known to occur to the south at West Point in King William County. It is not at this time known whether they underlie any portion of the Northern Neck.

Cretaceous sediments, in previous works on the Coastal Plain, have been subdivided into the Lower Cretaceous, Potomac Group ~~and~~ the Upper Cretaceous, Mattaponi Formation. Teifke designates the intermediate strata of Early Cretaceous Age as "transitional beds" (Table 3). These "transitional beds" exist only in the northwestern half of Westmoreland County where their thickness is as much as 100 feet in the extreme northwest. Apparently, in the remainder of the Northern Neck, including the areas as far west as Erica and Coles Point, these "transitional beds" have been completely eroded. The Cretaceous sediments were deposited in a fluvial-deltaic environment (Cederstrom, 1945). In both the York-James Peninsula and the Middle Peninsula, the preserved, meandering channel facies of the fluvial (river) environment and the deltaic environment have been identified previously. In the Northern Neck area these sediments contain approximately 25-50% sand in most areas, with scattered localities and depths having as much as 75% sand (Brown, 1972). These sand units probably result in many good water-bearing beds.

The marine Mattaponi Formation of Paleocene Age is overlain by the Nanjemoy Formation and lies directly upon the Patuxent Formation. This occurs in the majority of the Northern Neck with the exception of northwestern Westmoreland County, where it lies directly upon the "transitional beds". Thus defined, the Mattaponi interval includes rocks referred to as the Aquia Formation and is comprised of beds of quartz-glauconite sand, drab-colored, glauconite-bearing clay, shell beds, and an occasional bed, or beds, of indurated calcitic rock. Water-bearing, basal gravel is a subordinate lithologic type of relatively local occurrence. Abundant autochthonous (formed in place) glauconite is the principal lithologic criterion used to identify the unit (Teifke, 1973). The thickness of the Mattaponi is between 80 and 200 feet (Teifke, 1973). The elevation of the top of the Mattaponi Formation dips from -60 feet (msl) in the western tip of Westmoreland County to lower than -500 feet (msl) along the Chesapeake Bay, Northumberland County boundary.

The Nanjemoy Formation is comprised of sediments generally considered to be of Eocene age. The Nanjemoy, as defined by Teifke, is equivalent to sediments of Claiborne age, as described by Brown (1972). This formation is a succession of beds of sand, clay and calcitic units deposited under marine conditions. The beds of sand are mineralogically simple, consisting primarily of varying proportions of quartz and glauconite. They range from brown clayey beds of sand in which glauconite is a minor constituent to beds of clean "greensand", in which glauconite may constitute as much as 90 percent of the grains (Teifke, 1973). At the base of the Nanjemoy is the distinctive, pink, Marlboro clay. The thickness of the Nanjemoy Formation is generally at least 100 feet in the Northern Neck. It thins to as little as 40 feet in the westernmost part of Westmoreland County and in the coastal portions of Lancaster County, evidencing the relatively low filled basin in between. The elevation of the top of the Nanjemoy dips east-southeast from mean sea level in the far west of Westmoreland County to -420 feet (msl) on the coast of Lancaster County.

The Calvert Formation, of late Eocene to early Miocene age, includes all strata between the top of the Nanjemoy and the base of the Yorktown, or the base of the Columbia Group in the absence of the Yorktown Formation. It is the most widespread geologic unit in the Northern Neck. The Calvert Formation outcrops in the western halves of Westmoreland and Richmond counties. Although, in the area of the outcrop, it is less than 50 feet thick, maximum observed thicknesses of the total Calvert section include 332 feet in Northumberland County (Town of Ditchley, 166-14). The altitude of the top of the formation grades from over 100 feet above mean sea level in the western portions of the Study Area to below sea level in the coastal areas. The Calvert Formation generally can be divided into three parts: the basal sand member, the diatomaceous member and the upper member. The water-bearing, basal sand member generally consists predominantly of sand beds with minor clay beds of lenses. The principal constituents of the sands are usually clear, polished quartz and 5-15 percent reworked phosphorite. This is known as the most highly phosphoritic zone in the entire Coastal Plain section and causes a marked inflection in gamma-ray logs. The diatomaceous beds are pale brown to buff in color and uniform in texture; they contain very little sand or silt. The upper member consists primarily of greenish-gray to brownish-gray, silty clay and interbedded accumulations of mollusk shells (Teifke, 1973).

The Yorktown Formation, of late Miocene age and possibly Pliocene age in its uppermost part, consists of the marine sediments between the top of the Calvert Formation and the base of the Columbia Group. The Calvert differs from the younger Yorktown in that the latter has more abundant and coarser-grained sand-and-gravel units, and more abundant and thicker shell beds. The Yorktown is also lighter in color than the upper member of the Calvert (Teifke, 1973).

The Columbia Group consists of all sediments which overlie recognizable Yorktown or Calvert strata. These younger, non-marine deposits, Pliocene through Recent in age, cover most of the Yorktown and older rocks in the Study Area. Oxidized clays. silts. sands and gravels constitute most of the deposits. In most places the sediments of the Columbia Group contrast sharply with any marine formation which they overlie.

Groundwater Availability

Groundwater of the Northern Neck occurs in three major aquifer systems (Table 4 and Appendix F). The uppermost aquifer system, the water-table aquifer, is found throughout the area. It consists of unconsolidated deposits of Tertiary and Quarternary Age (primarily the Columbia Group and the Yorktown Formation). The second aquifer system of the Northern Neck is the upper-artesian aquifer system of Eocene age, which is formed from sediments of the Calvert Formation near the Chesapeake Bay and some sediments from the top of the Nanjemoy Formation near Warsaw and westward. The third aquifer system, the principal-artesian aquifer system, comprised of Paleocene ~~and Cretaceous~~ Age sediments (Patuxent and Mattaponi Formation) is found throughout the entire peninsula. In addition, there is a minor, second, upper artesian aquifer system of Miocene age throughout the area. This system, however, is comprised of sands which are generally too fine to yield enough water to be worthy of development.

Specific capacity, defined as gallons per minute of withdrawal per foot of drawdown (gpm/ft) is the most reliable hydrogeologic information available for most of the wells in the Northern Neck. Therefore, specific capacity is used in this report as an indicator of aquifer potential. It should be noted that variations in well construction and development will have pronounced effects on the specific capacity of a well. In those areas, however, where specific capacities are reproted accurately and well completion information is available, specific capacities can be used as a reasonable comparative parameter of aquifer potential.

For wells on which construction data and geophysical logs are available, specific capacities have been corrected by means of a graph. The graph has been constructed from the Kozeny formula which compensates for well diameter, well construction and partial penetration of the aquifer (Johnson, 1972).

Principal Artesian Aquifer. The principal-artesian aquifer system in the Northern Neck has a relatively large well-yield potential (200 gpm (757L/min)). The system is composed of many sands from the Mattaponi and Patuxent formations that have a high potential yield from depths which vary from 300 feet below sea level in the western third of the Study Area to nearly 600 feet below sea level in Lancaster County (Plate 4). The topography of the basement rock complex, the presence of faults in the basement, the percentage of sand in the aquifer and the thickness of the aquifer control the hydrology of the aquifer (State Water Control Board, 1973). The lithology can be extremely variable, even within short distances. Aquifer sand-percentage is higher in the areas where sands were deposited by meandering river channels than in areas where sands were deposited by tributary stream channels. The thickness of the aquifer system increases to the eastern and northeast portion of the Study Area. The Aquia greensand, at the top of the Mattaponi Formation, supplies most of the public supply wells in nearby St. Marys County, Maryland.

Water requirements and economic factors normally determine well design. The installation of multiple, short screens in the various sands, rather than a single, long screen is the most efficient method of obtaining large yields for this area. Well yields obtained from this aquifer system in the Northern Neck predominantly are affected by the percentage of sand composition and the well design. In order to increase the delivered volume, the screen or screens are set in the smallest reasonable diameter, which is then enlarged upwards. Small diameter wells (6 inch diameter telescoped to 4 inch or 4 inch diameter telescoped to 2 inch) with screens in only a small portion of the aquifer, are constructed when only low well-yields are required (Table 4 and Appendix B). When higher yields are sought, larger diameter (untelescoped six inch or greater) wells are necessary. High-yield wells often are designed with multiple, short screens placed adjacent to all the major sand strata encountered. The largest well yields recorded include 503 gpm (1904 L/min) at Haynie Products in Northumberland County (well 166-26) and 844 gpm (3195 L/min) at Arrowhead Manufacturing in Westmoreland County (well 196-17).

Like actual well yields, specific capacities of wells developed in the principal aquifer are also dependent upon well design and aquifer characteristics. Specific capacities of small-diameter wells, designed as previously discussed, range from 0.5 gpm/ft (6.21 L/min/m) to 3.3 gpm/ft (41.0 L/min/M) (Table 4 and Appendix B). Specific capacities of the above mentioned large diameter wells range from 2 gpm/ft (24.84 L/min/M) to 15.7 gpm/ft (195.0 L/min/m). The highest specific capacities on record for wells developed in the principal aquifer system include 15.7 gpm/ft (195.0 L/min/m) of Haynie Products of Northumberland County (well 166-26) and 12.9 gpm/ft (160.2 L/min/m) at Cabin Point Subdivision in Westmoreland County (well 196-24). The largest specific capacities have been obtained from extensively developed wells having screens in the majority of the sands available and having been adequately gravel-packed. Table 4 depicts the great variation in yields, as well as specific capacities, of wells (see also Appendix B) throughout the area.

Upper Artesian Aquifer. This system has a fairly consistent thickness of about 60 feet. At George Washington's Birthplace in Westmoreland County this system consists of silty, glauconitic sand layers with relatively low yields expected. This Eocene age aquifer is the first, good, water-bearing horizon beneath the poorly productive Yorktown Formation of Miocene Age. The consistency of this upper system makes it a reliable source of individual, domestic, and possibly subdivision groundwater supply in both the Northern Neck of Virginia and St. Marys County of Maryland. Primarily in a zone trending north-south from east of Montross to the Morattico area, this system now provides groundwater for many light-to-moderate water users.

The upper artesian aquifer system generally has a low-to-moderate well-yield potential, 20 gpm (75.7 L/min) to 110 gpm (416.4 L/min). Specific capacities for wells developed in the upper artesian aquifer

TABLE 4

CHARACTERISTICS OF AQUIFERS IN THE NORTHERN NECK*

		Well Yields		Specific Capacities	
	Approximate Depth to top of Aquifer (ft)	Well Diameter Less Than 6 in. (gpm)	Well Diameter 6 in. or Greater (gpm)	Well Diameter Less Than 6 in. (gpm/ft)	Well Diameter 6 in. 20 in X 8 in. (gpm/ft)
Upper Artesian					
Eastern Half	325 - 375	20 - 40	30 - 75	.1 - .5	.1 - .6
Western Half	225 - 325	20 - 110	50 - 60	.1 - 1.6	.7 - 2.1
Principal Artesian					
Eastern Half	500 - 600	40 - 200	100 - 503	1.0 - 3.3	3.0 - 15.7
Western Half	350 - 500	40 - 100	60 - 844	.5 - 1.3	1.0 - 12.9

* Individual well data is found in Appendix.

** The lower limit is indicative of 4 X 2 or 2 inch diameter wells. The Upper limit is indicative of 6 X 3 inch diameter wells.

system are much lower than specific capacities for wells in the principal aquifer system. This is especially true when comparing the larger diameter wells in both systems (Table 4 and Appendix B).

Most wells that have been developed in the upper artesian aquifer system are small diameter wells which yield 20 gpm (75.7 L/min) to 40 gpm (151.4 L/min) (Table 4 and Appendix B). The larger diameter wells (six to eight inches in diameter) which tap the upper artesian system exhibit some variability across the Study Area. Yields of 30 gpm (113.5 L/min) to 40 gpm (151.4 L/min) are normal in the eastern half of the Study Area, with yields of 50 gpm (189.3 L/min) to 60 gpm (227.1 L/min) common in the western half. The slightly greater yields in the western portion are attributed to the greater permeability of the aquifer there. The largest yields on record for the upper artesian ~~aquifer~~ are 75 gpm (283.9 L/min) near Ditchley in Northumberland County and 110 gpm (416.4 L/min) at Sanford Canning near Hague in Westmoreland County.

Water Table Aquifer. This important aquifer system occurs generally under water table conditions, but locally in the eastern portion of the Study Area, it occurs under some artesian pressure. The water table aquifer is especially important in eastern Lancaster and Northumberland Counties where it is not uncommon for the upper and principal artesian systems to be quite brackish and, therefore, unsuitable for potable use (see Chapter IV).

The water table aquifer system consists of discontinuous lenses of generally fine sand and shells as thick as 30 feet. Specific capacities generally range from one to three gpm/ft., and reported yields throughout the system generally range from 5 to 20 gallons per minute. This unconsolidated aquifer is a source of domestic groundwater supply in most of the Study Area, but seasonal fluctuations and lack of sufficient storage make it impractical for any except minor supplies.

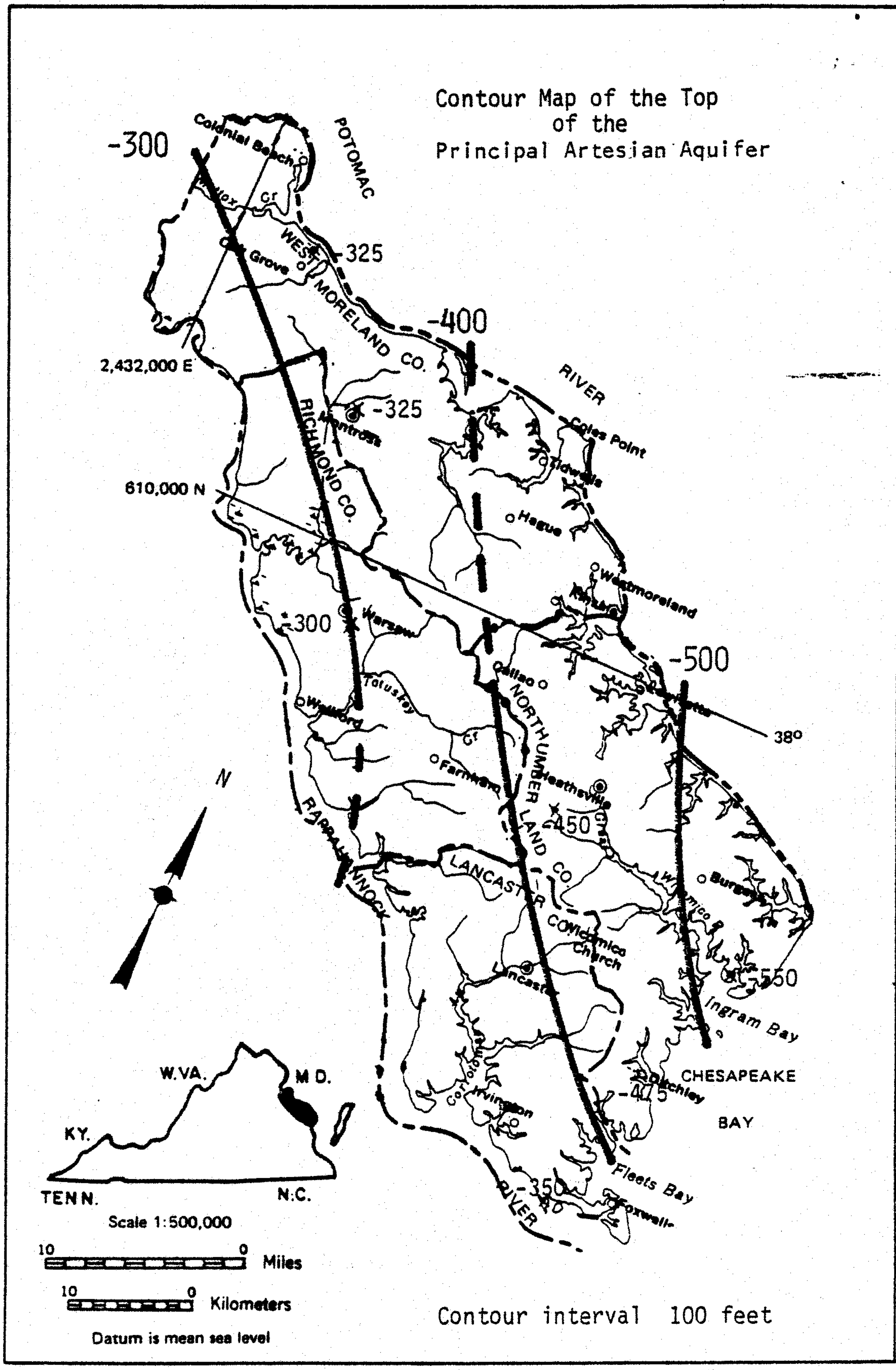
State Water Control Board data files show that the unconsolidated, water table aquifers are a significant source of domestic groundwater in the Northern Neck. These aquifers also supply groundwater to some institutions, farms, and other small users in the area.

Elevation of Aquifers

The elevation or altitude relative to mean sea level of each aquifer determines the approximate distance needed to drill in order to obtain water from that aquifer. A more exact depth can be determined by adding the elevation of the top of the aquifer to the elevation of the well site. The latter elevation can be obtained from the appropriate U. S. Geological Survey topographic map.

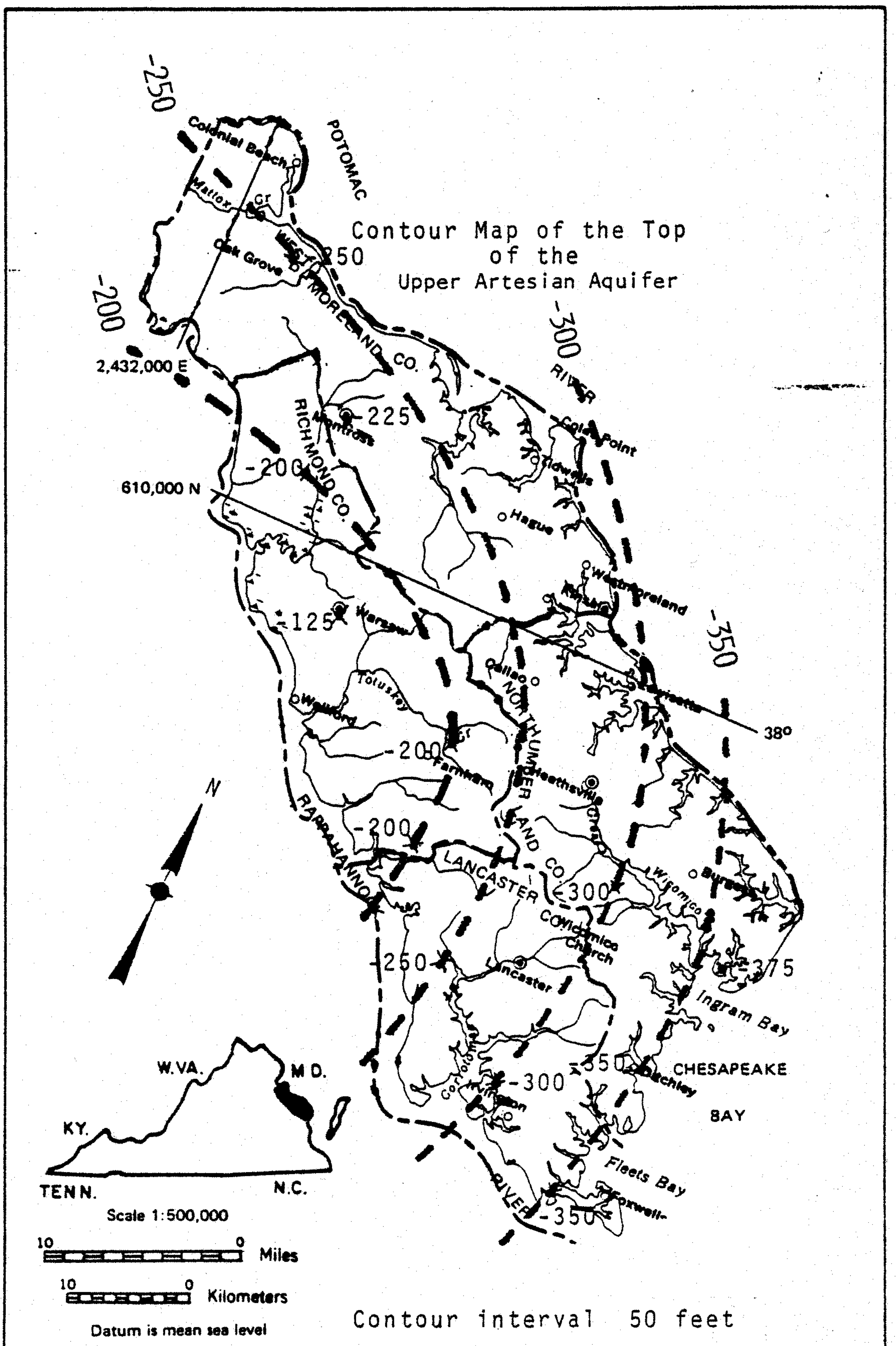
The principal artesian aquifer sands tend to dip to the east in the Study Area, from -300 feet msl along the Rappahannock River to

-550 feet msl (Plate 4) in the Reedville area. The upper artesian aquifer system is prominent on all the geophysical logs of the area that were examined. It dips slightly east-southeast from approximately -200 feet msl west of Warsaw to -375 feet msl in the Reedville area (Plate 5).



Source: Brown, et. al. (1972)

Plate 4



Source: Brown, et. al. (1972)

Plate 5

CHAPTER IV

GROUNDWATER HYDROLOGY

Hydrologic data on the artesian aquifer systems in the Northern Neck consist primarily of specific capacity determinations from single-well pumping tests. Stratigraphic correlations, assembled from geophysical well logs and well sections give a reasonable interpretation of the hydrologic framework of the artesian aquifer.

Substantial recharge occurs from vertical leakage between adjacent aquifers through aquitards. The rate of vertical flow is proportional to the difference in water levels in adjacent aquifers and effective vertical permeability. With heavy pumpage and increasing pressure differentials, leakage can yield substantial quantities of water to pumped aquifers.

A minimum value for leakage through the confining layer of the Principal Aquifer system can be estimated by using Darcy's Law, Q = PIA, where Q = recharge in gallons per day; P = permeability (the capacity to transmit water) of the confining layer; I = hydraulic gradient, which in this case, is the ratio of the head differential to the thickness of the confining layer; and A = areal extent of confining layer (U.S.G.S. Water Supply Paper 1536-E).

The nearest core from the Virginia Coastal Plain that has been tested in the laboratory was of a very low permeability clay taken from Well 118-49 in Charles City County. The permeameter tests show an average permeability of 0.0025 inches per day, which is equal to 0.0015 gallons per day per square foot. In the West Point area, head differentials between two aquifers separated by a 70-foot thick confining layer vary between 40 feet and 60 feet. Assuming an average head differential of 50 feet, the hydraulic gradient imposed on the confining layer is 50 ft/70 ft or 0.71. For an area of one square mile, the recharge derived from leakage through the confining bed is:

$$Q = 0.0015 \text{ gpd/ft}^2 \times 0.71 \times (5.28 \times 10^3 \text{ ft})^2$$

$$Q = 0.0305 \times 10^6 \text{ gpd} = 30{,}500 \text{ gpd}$$

This estimate of leakage is a minimum value. Clay as impermeable as that in the core sample from Well 118-49 is not often found. The confining layer is usually made up of more silty material in which a permeability increase of one order of magnitude can be expected. The head differential in the West Point area is lower than normal because of heavy pumpage in both of the aquifers separated by the confining bed.

Transmissibility Values

In 1974, an aquifer-pump-test was conducted at the George Washington Birthplace National Monument in northwestern Westmoreland County. This test, as described by Lichtler (1975), is the only one that has been conducted in the Northern Neck that has utilized a production well and an observation well, both screened in the uppermost portion of the principal aquifer system (Table 5). Transmissibility values, calculated using the modified-nonequilibrium formula of Jacob, were 14,700 gpd/ft (1825.7 Lday/ft) for the pumping well and 27,500 gpd/ft (3415.5 L/day/ft) for the observation well. Transmissibility values determined using the nonsteady-state, leaky-artesian formula were somewhat lower: 13,300 gpd/ft (1651.8 L/day/ft) for the pumping well and 22,800 gpd/ft (2831.8 L/day/ft) for the observation well. Lichtler concluded that the transmissibility value ~~obtained~~ from the producing well using an average of the values obtained by the two methods, 14,000 gpd/ft (1738.8 L/day/m), is more nearly representative of the producing aquifer system than the values obtained from the observation well. A storage coefficient also was determined for the observation well using the nonsteady-state leaky-artesian method.

Only larger diameter wells were used in making the transmissibility estimates, since specific capacities from wells with less than a 6-inch diameter reflect well-design characteristics and not aquifer characteristics. This trend is shown in Table 6, where it can be seen that specific capacity values for smaller diameter wells in the principal artesian aquifer and the upper artesian aquifer are similar. If determined by aquifer characteristics the specific capacity values would be expected to be higher for the principal artesian aquifer. As well design is the dominant determining factor for these values, they can not be used in accurate transmissibility determinations.

Since no other aquifer pump-test data utilizing an observation well are available, rough estimates of transmissibility values were calculated from available specific capacity data. The theoretical specific capacity of a well discharging at a constant rate in a homogenous, isotropic, nonleaky, artesian aquifer, infinite in areal extent, is given by the following equation:

$$\frac{Q}{s} = \frac{T}{264 \log \frac{Tt}{2{,}693 r_w^2 S} - 65.5}$$

Where $\frac{Q}{s}$ = specific capacity, in gpm/ft

Q = discharge, in gpm

s = drawdown, in feet

T = coefficient of transmissibility, in gpd/ft

S = coefficient of storage, fraction

r_w = nominal radius of well, in feet

t = time after pumping started, in minutes

Table 5. Summation of aquifer test July 24-25, 1974 at George Washington Birthplace National Monument. (Westmoreland County)

SWCB WELL NUMBER	DEPTH OF WELL (FEET)	SCREENED INTERVAL	DISTANCE FROM PUMPED WELL (FEET)	TRANS MISSIVITY gal/day/ft	STORAGE COEFFICIENT	MAXIMUM DRAWDOWN (FEET)	REMARKS
57	452	394-409 442-447	0	14,700	-	25.88	Pumped well modified nonequilibrium method pumping rate 150 gpm
57	452	394-409 442-447	0	13,300	-	25.88	Pumped well nonsteady state leakey artesian method
2	471	451-466	2,250	27,500	-	1.40	Observation well modi fied nonequilibrium method
2	471	451-466	2,250	22,800	0.0002	1.40	Observation well nonsteady state leaky artesian method

This equation assumes that : (1) the production well penetrates, and is uncased, through the total, saturated thickness of the aquifer. (2) well loss is negligible, and (3) the effective radius of the production well has not been affected by the drilling and development of the production well and is equal to the nominal radius of the production well.

The relationships between the specific capacity and the coefficient of transmissibility for artesian and water-table conditions are shown in graphs C, D, and E of Plate 6. Pumping periods of 1 hour, 8 hours, and 24 hours; a radius of 6 inches; and storage coefficients of 0.0001 and 0.02 were assumed in constructing the graphs. These graphs may be used to obtain rough estimates of the coefficients of transmissibility from specific-capacity data (Walton, 1970). The coefficient of storage is estimated from well-log and water-level data, and a line based on the estimated S is drawn parallel to the lines on one of the graphs C, D or E in Plate 6, depending upon the pumping period. The coefficient of transmissibility is selected from the point of intersection of the S line and the known or corrected specific capacity.

Specific capacity data were corrected for partial penetration and well radius using the relationships in graphs A and B of plate 6. A storage coefficient of 0.0001 was assumed from the aquifer pump test discussed above.

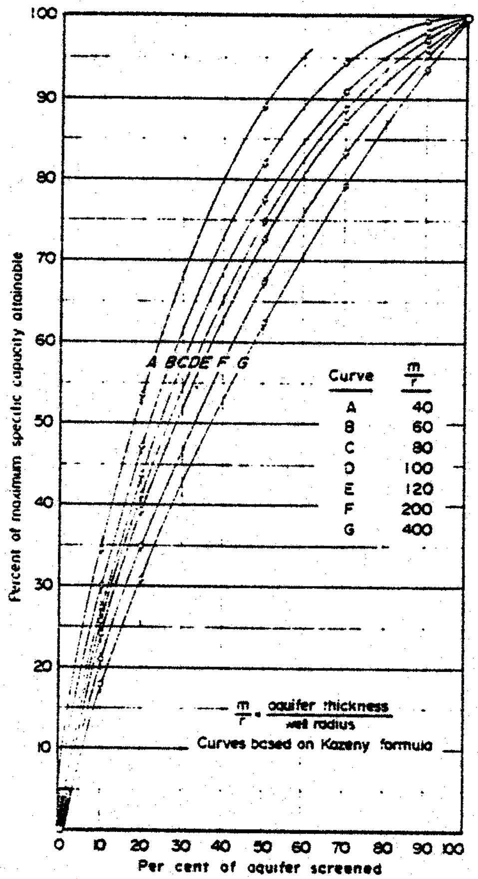
Transmissibilities for the principal artesian aquifer, as determined from specific capacities, are shown in Table 5. The transmissibility estimate for the George Washington Birthplace Monument well is reasonably close to the transmissibility calculated from the aquifer pumping test. As the aquifer pump test value was 14,000 gpd/ft (1738.8 L/day/m) and the estimated value was 18,000 gpd/ft (2235.6 L/day.m), the transmissibility estimates in Table 5 are considered to be good rough estimates (±22%) of the transmissibility of the upper portion of the principal artesian aquifer system. Determination of transmissibilities of the lower portion of the principal aquifer is not possible at the present time due to the lack of relevant data.

Very few larger diameter wells have been completed in the upper artesian and water table aquifers. This greatly inhibits estimation of transmissibilities from specific capacity data (Table 5). Transmissibility estimates for the upper artesian aquifer range from less than 1000 gpd/ft (124.2 L/day/ft) to 3,500 gpd/ft (434.7 L/day/ft). Transmissibility estimates for the water table aquifer range from 2000 gpd/ft (248.4 L/day/ft) to 4000 gpd (496.8 L/day/ft). More specific capacity data and aquifer pump test data are needed for this upper artesian aquifer and the water table aquifer.

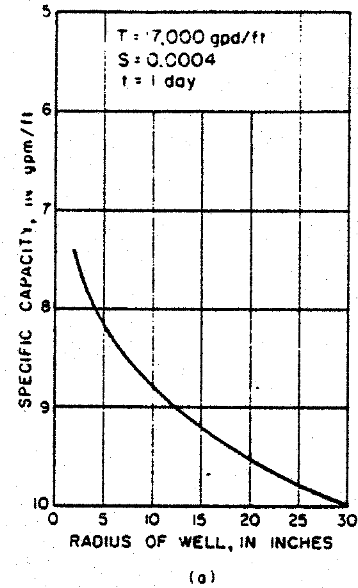
Transmissibilities also were calculated using available well yield tests. Available pump test and recovery test data were plotted and analyzed using the Modified Nonequilibrium Formula and the Theis Recovery Formula respectively (Ferris, 1962). The formulas are similar in form:

Graphs Used in Estimating Transmissibilities

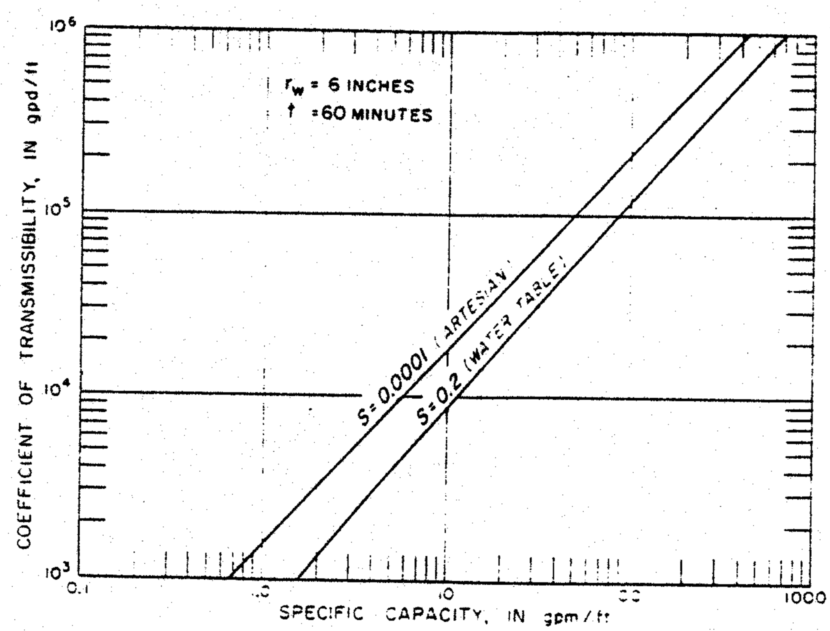
From Selected Specific Capacity Data



A. **Relationship of partial penetration and attainable specific capacity for wells in homogeneous artesian aquifers.** (Johnson Division, 1972)



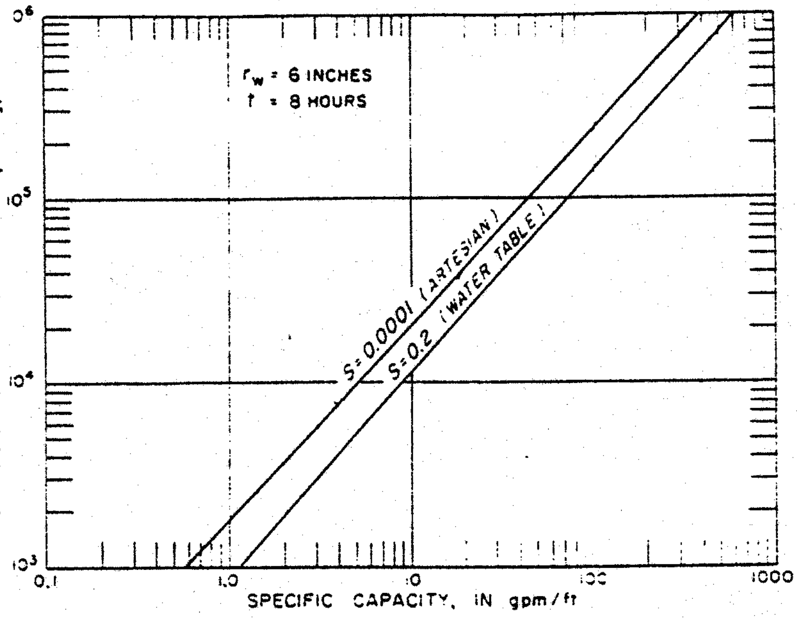
B. Graphs of specific capacity versus well radius *(From Walton, 1962.)*



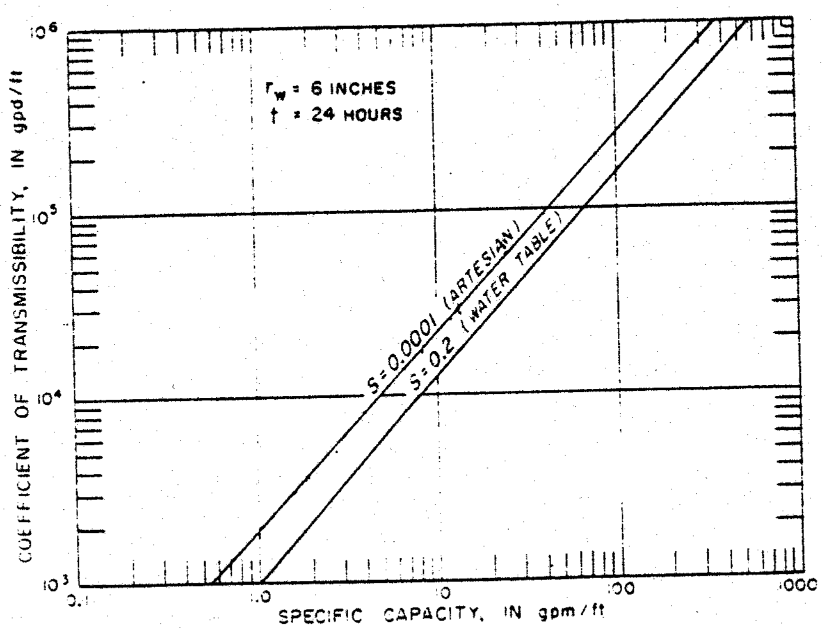
C. Graphs of specific capacity versus coefficient of transmissibility for a pumping period of 60 minutes. *(From Walton, 1962.)*

Plate 6

Plate 6 Continued.



D. Graphs of specific capacity versus coefficient of transmissibility for a pumping period of 8 hours. *(From Walton, 1962.)*



E. Graphs of specific capacity versus coefficient of transmissibility for a pumping period of 24 hours. *(From Walton, 1962.)*

$$T = \frac{264\ Q}{\Delta s}, \qquad T = \frac{264\ Q}{\Delta s'}$$

T is transmissibility, and Q is the rate of discharge or recharge. In the nonequilibrium formula, Δs is the change (in feet) in the drawdown or recovery over one log cycle of time. In the recovery formula, $\Delta s'$ is the change in residual drawdown (in feet) per log cycle of time.

Semilog plots were obtained of time versus water level (Appendix D). Using the Theis Recovery Formula and the nonequilibrium formula, transmissibilities for 11 wells on the Northern Neck were determined (Table 6A). These transmissibility values are considered to be one level of accuracy better than those values obtained from specific capacities. Generally, the transmissibility values calculated using the two methods compare well (Tables 6, 6A). The trend can be seen that wells which partially penetrate the upper part of the principal aquifer generally have lower transmissibility values such as wells 196-129 and 151-43. Transmissibility values obtained using the pump test versus the recovery test data at Cople Elementary School are very close. However, frequently pump test data are not usable because straight line plots of time versus drawdown data can not be obtained. Recovery test data in this study area and nearby areas frequently plots as a straight line and therefore is very useful in calculating transmissibility.

Groundwater Movement

Groundwater resource studies of the Northern Neck have been conducted by Sanford (1913) and Sinnott (1969). Selected data from these studies were used to prepare historical potentiometric surface maps of the area (Plates 7, 8, 9 and 10). These surfaces are, of course, approximations of the conditions for the time period indicated and there may be some location discrepancies among various researchers. However, the surfaces are reliable and accurate enough to determine trends in water levels and groundwater flow conditions.

TABLE 6

Estimated Transmissibility of
Selected Wells in the
Major Aquifers of the Northern Neck

Well No.	Diameter In.	Corrected** Specific Capacity gpm/ft	Approximate Transmissibility gpd/ft
Principal Artesian Aquifer System			
Lancaster County			
151-50	10 X 6	3.3*	7,000
Northumberland Co.			
166-28	18 X 10	5.8*	15,000
Richmond County			
179-7	8 X 6	3.5*	8,500
Westmoreland Co.			
196-2	6	4.4	9,000
196-17	20 X 8		18,000
196-23	10 X 8	4.5	15,000
196-24	10 X 8	13.6	30,000
196-43	6	1.8	4,500
196-57	6	8.6	18,000
Upper Artesian Aquifer System			
Richmond Co.			
179-4	6	2.2*	3,500
Westmoreland Co.			
196-30	6	0.7*	1,500
196-48	6	0.2*	Less than 1,000
Water Table Aquifer (Yorktown)			
Lancaster Co.			
151-6	6 X 4.5	1.2*	2,000
151-17	6 X 4.5	2.3*	4,000

*No correction necessary, actual specific capacity.

**Corrected specific capacities obtained from the relationship shown in Plate A.

TABLE 6A

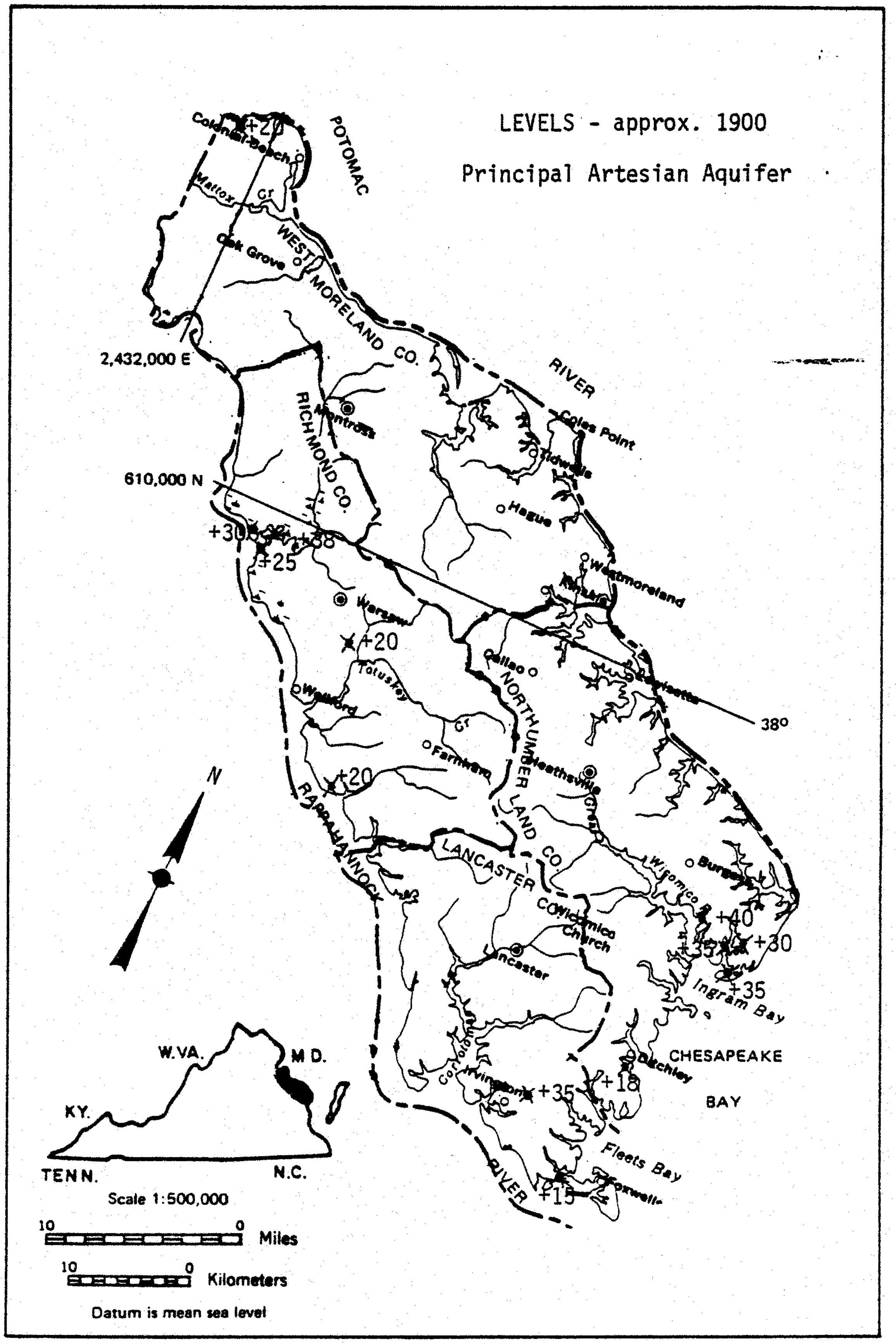
Transmissibility Values Determined
From Well Yield Tests
(See Appendix D)

Well No.	Description	Transmissibility Pump Test gpd/ft	Transmissibility Recovery Test gpd/ft
Principal Artesian Aquifer System			
Lancaster County			
151-43	Tides Inn	4,020	----
151-50	West Irvington	17,700	----
151-83	Town of Kilmarnock	----	23,820
Northumberland County			
166-26	Haynie Products	----	34,670
166-28	Standard Products	----	23,210
Westmoreland County			
196-2	George Washington Birthplace Park	10,590	----
196-17	Arrowhead Industries	15,010	----
196-23	Cabin Point Subdivision	----	17,100
196-57	George Washington Birthplace	----	16,000
196-129	Westmoreland State Park	----	2,160
196-136	Cople Primary School	11,640	11,930
Upper Artesian Aquifer			
Westmoreland County			
196-12	Sanford Canning	6,600	----

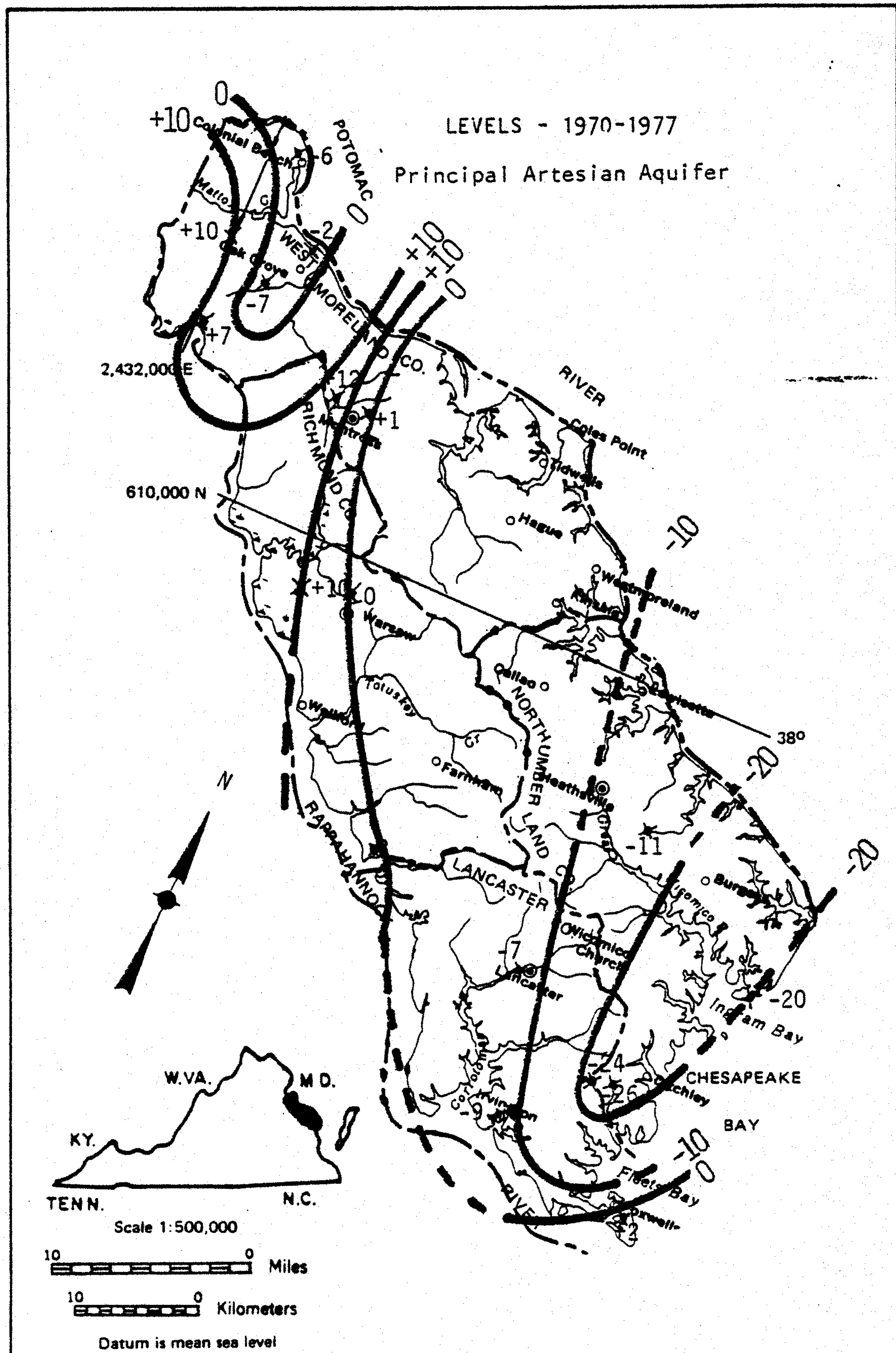
Principal Aquifer System. Between 1900 and 1977 pumpage lowered levels overall by approximately 15 to 20 feet. This is reflected in both the hydrographs in Plate 13 and the levels maps (Plates 7 and 8). The hydrographs show a 15-foot drop in the past 10 years. This is probably because both observation wells are located in major towns. As the population of the town has increased, the amount of the withdrawal has also increased.

Two low areas are shown in Plate 8. One is in the Reedville-Fairport area and one is in the Colonial Beach area. These are the two most developed and rapidly growing areas of the peninsula.

Upper Artesian Aquifer. The potentiometric surface of the upper artesian system for the year 1900 (Plate 9) shows that the flow was generally from west to east-southeast. Between 1900 and 1977 the levels declined overall by approximately 10-20 feet (Plates 10 and 11). A possible low area is delineated in the Lewisetta area. This may be caused by aquifer discharges to the Potomac River.

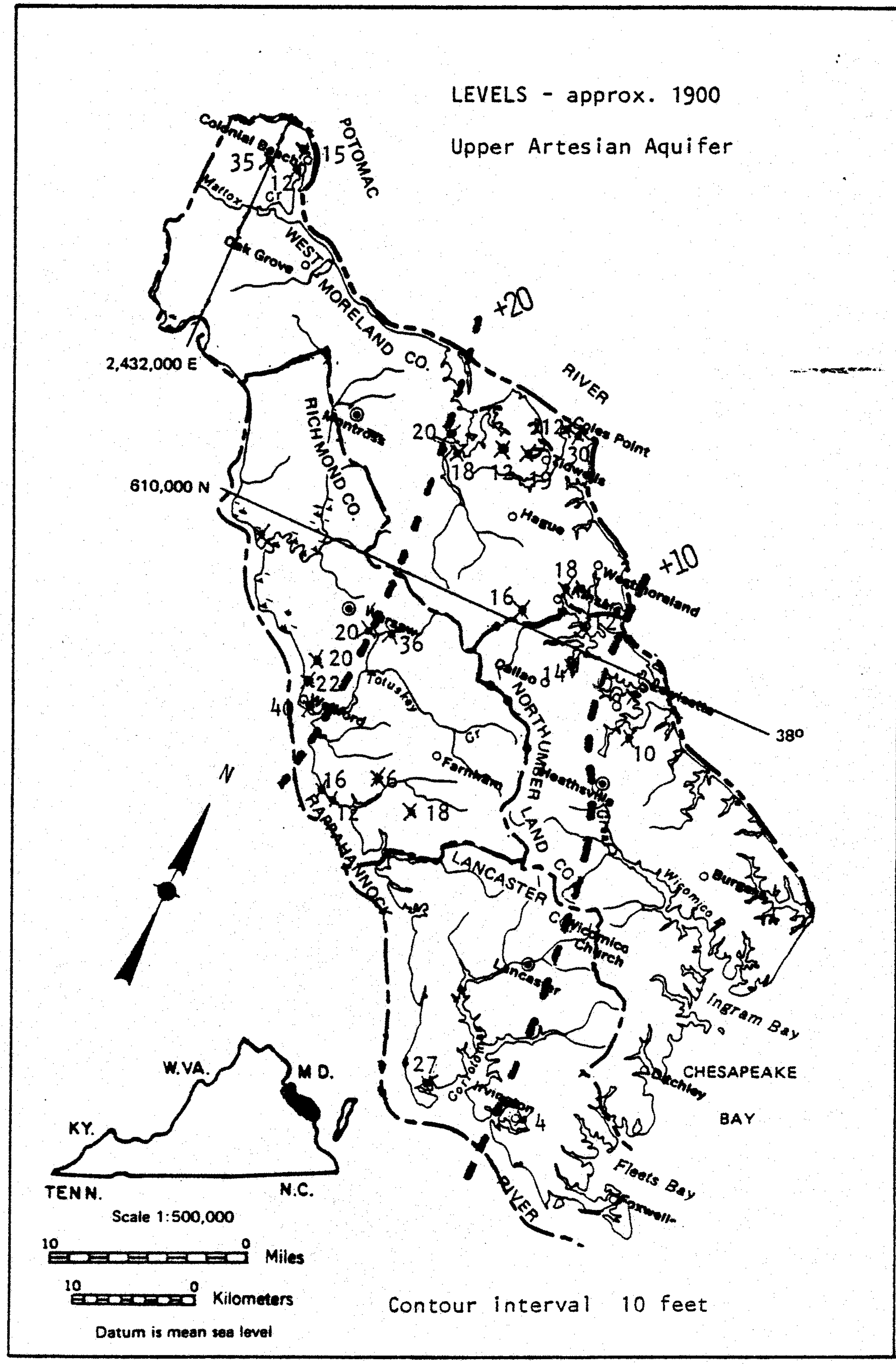


Source: Sanford (1913) and Sinnott (1969) Plate 7



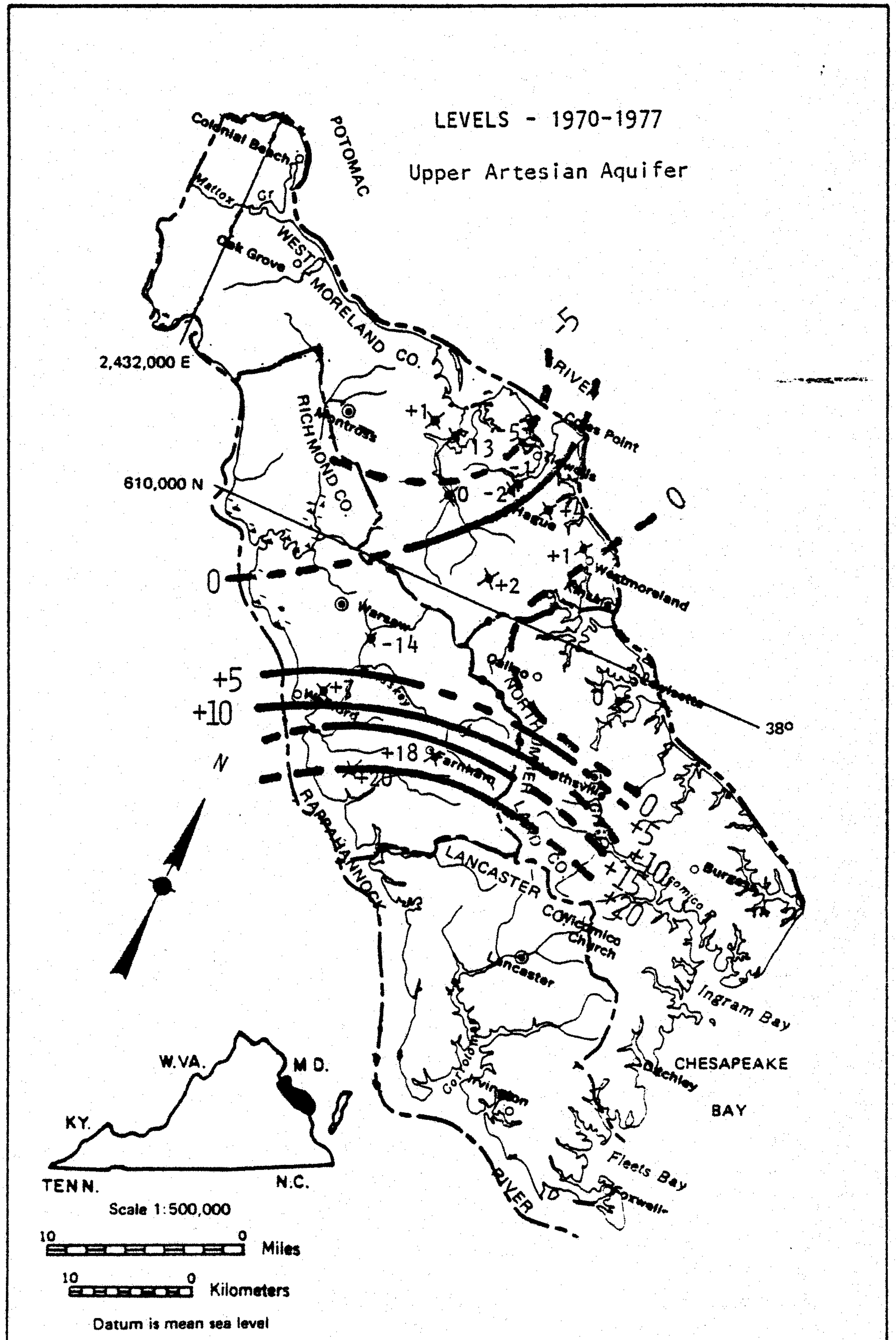
Source: Virginia State Water Control Board

Plate 8



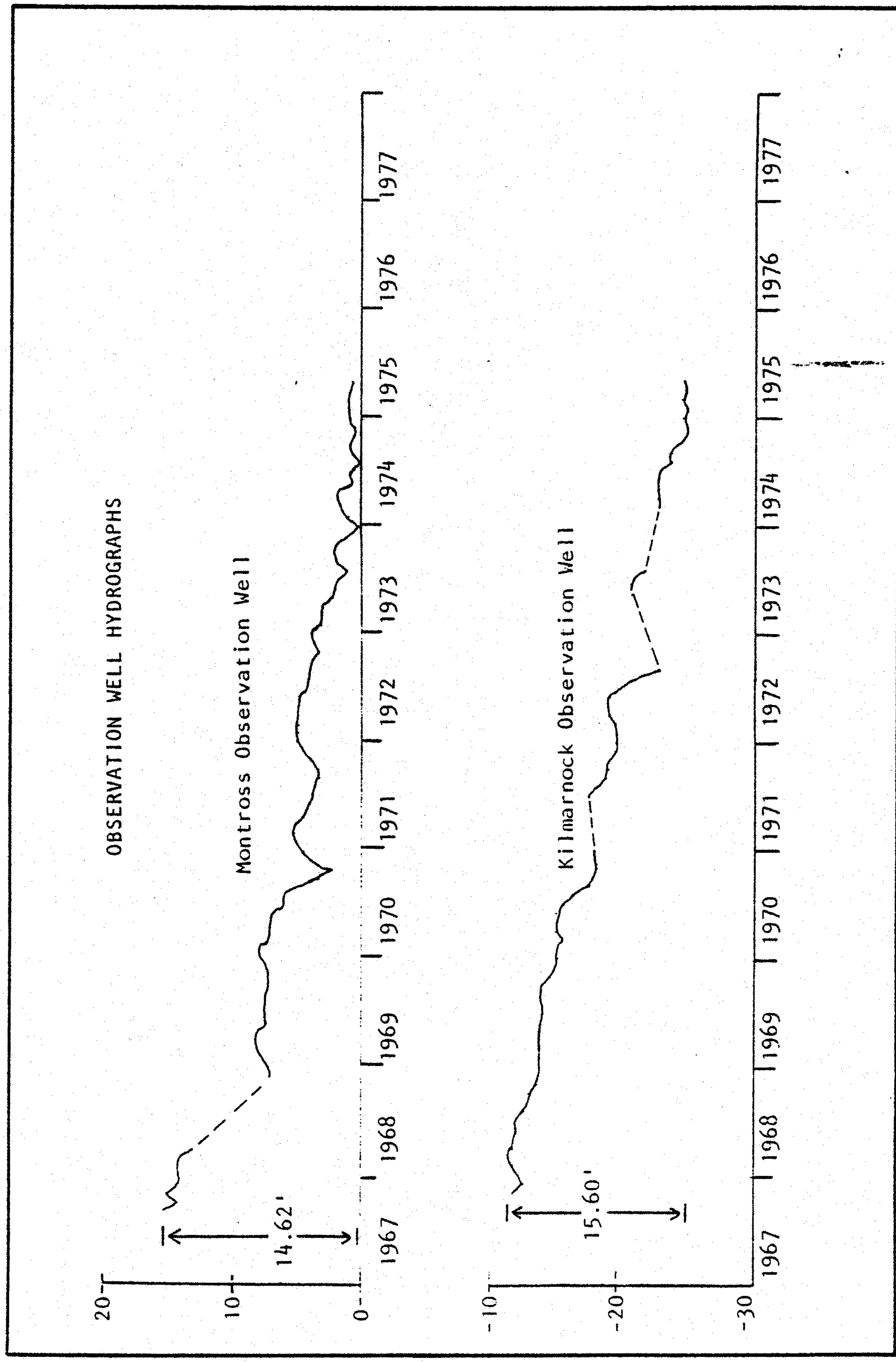
Source: Sanford (1913) and Sinnott (1969)

Plate 9



Source: Virginia State Water Control Board

Plate 10



Source: Virginia State Water Control Board

Plate 11

CHAPTER V

GROUNDWATER QUALITY

General Groundwater Quality

Both groundwater and surface water contain various dissolved chemical constituents which affect overall quality and usefulness. Because it is exposed to so many factors which can have a direct effect on it, surface water generally will exhibit a higher concentration and greater variety of these dissolved chemicals than groundwater. Groundwater is affected primarily by the soil and/or rock environment through which the water ciruclates. Man's activities may have an immediate impact upon surface water quality, while, in most cases, man's impact on groundwater quality is not as immediate or apparent. The ~~effects~~ upon groundwater, however, may be much more severe since pollutants in groundwater tend to be more long-lived and persistent.

The chemical constituents and their concentrations will vary from one area to another depending upon the geology of the area. Generally speaking, groundwater is colorless or near colorless, clean, and has a constant temperature equivalent to the average annual, atmospheric temperature of the region where it occurs (in the Northern Neck, about 58° F. or 14° C.).

Although numerous properties can be determined when evaluating water quality, only the most important will be included in the following discussions. More complete analyses are listed in Appendix B.

Results of these analyses usually are expressed in parts per million (ppm) or in the metric system as milligrams per liter (mg/l). These two terms can be used interchangeably in describing water quality analyses.

Principal Artesian Aquifer. The principal artesian aquifer system has large reserves of excellent quality water which is utilized throughout much of the study area. The water is of a soft, sodium bicarbonate type, as is the water in the corresponding principal aquifer in nearby St. Marys County, Maryland. In the southeastern-most tip of Northumberland County the chloride values are slightly higher than normal (Plate 12 and Table 7) ranging from greater than 5 ppm to as much as 169 ppm.

This high chloride zone was identified by Cederstrom (1946) and is not confined to the Northern Neck. It extends south to the Middle Peninsula, York-James Peninsula and southeastern Virginia, and to the east on the Virginia Eastern Shore. It is believed that the salinity or high chlorides of the artesian aquifer of the Virginia Coastal Plain is a result of incomplete flushing of sea water from these aquifers since they were last saturated during the Holocene marine transgressions.

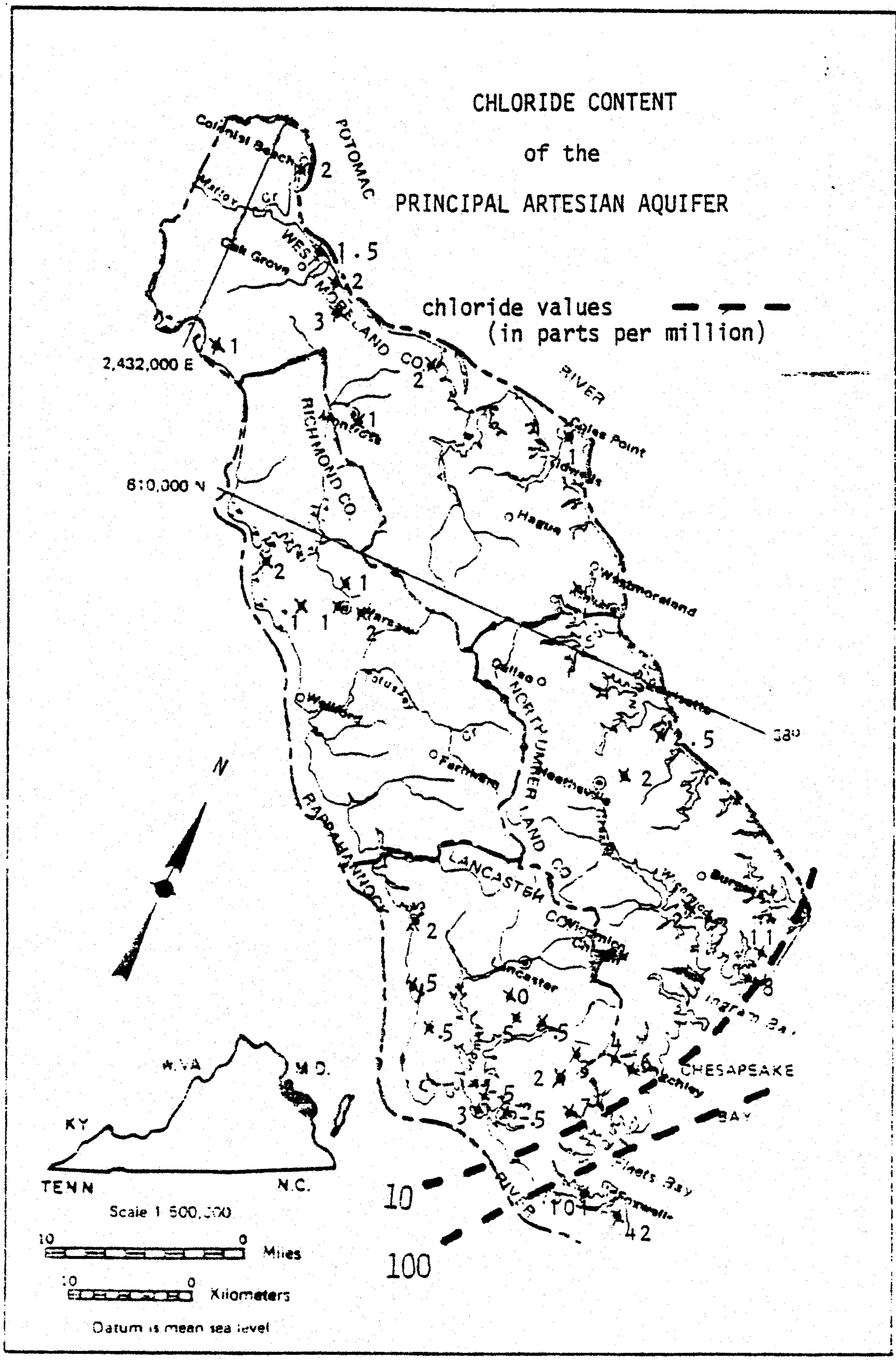
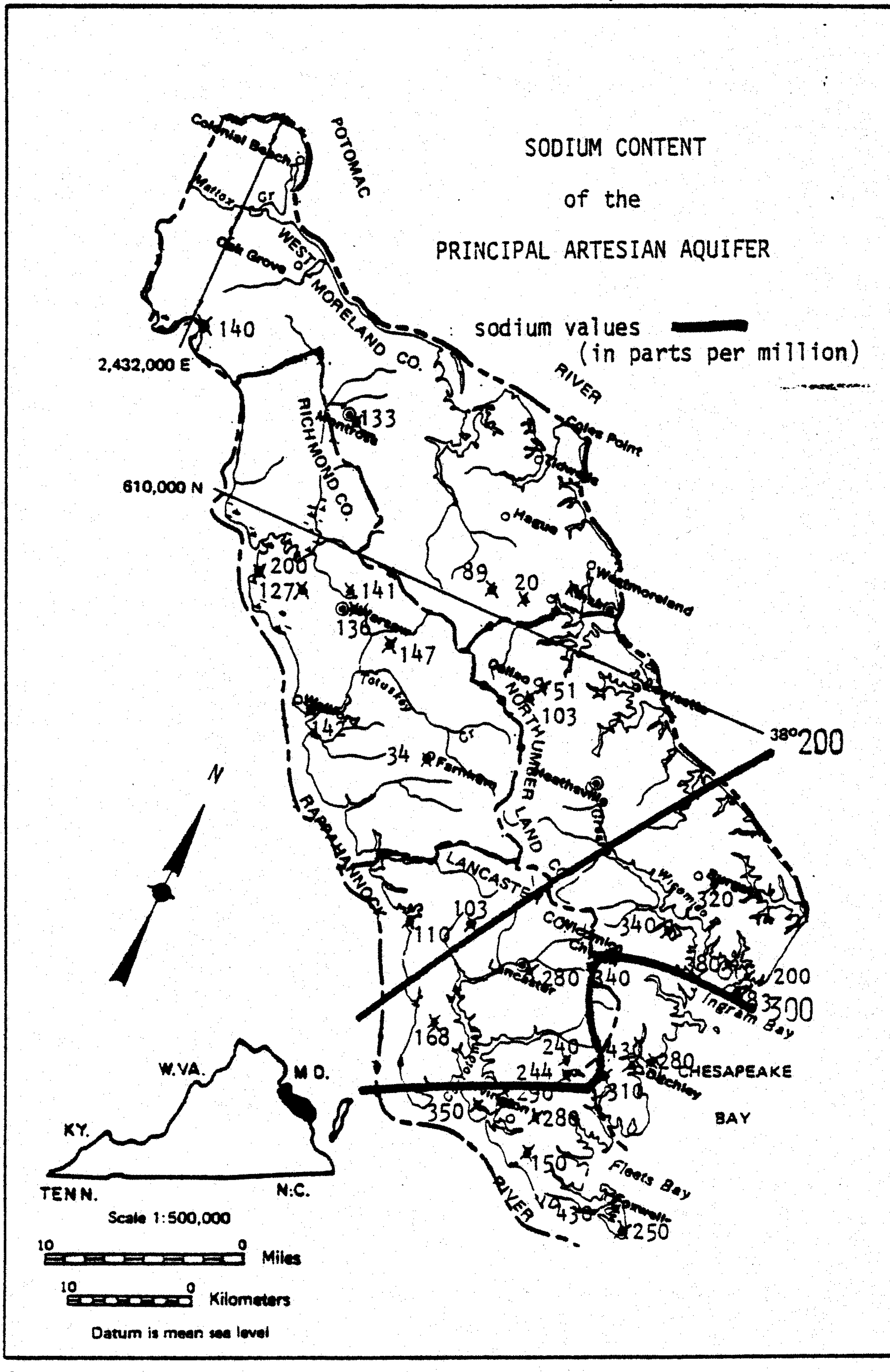
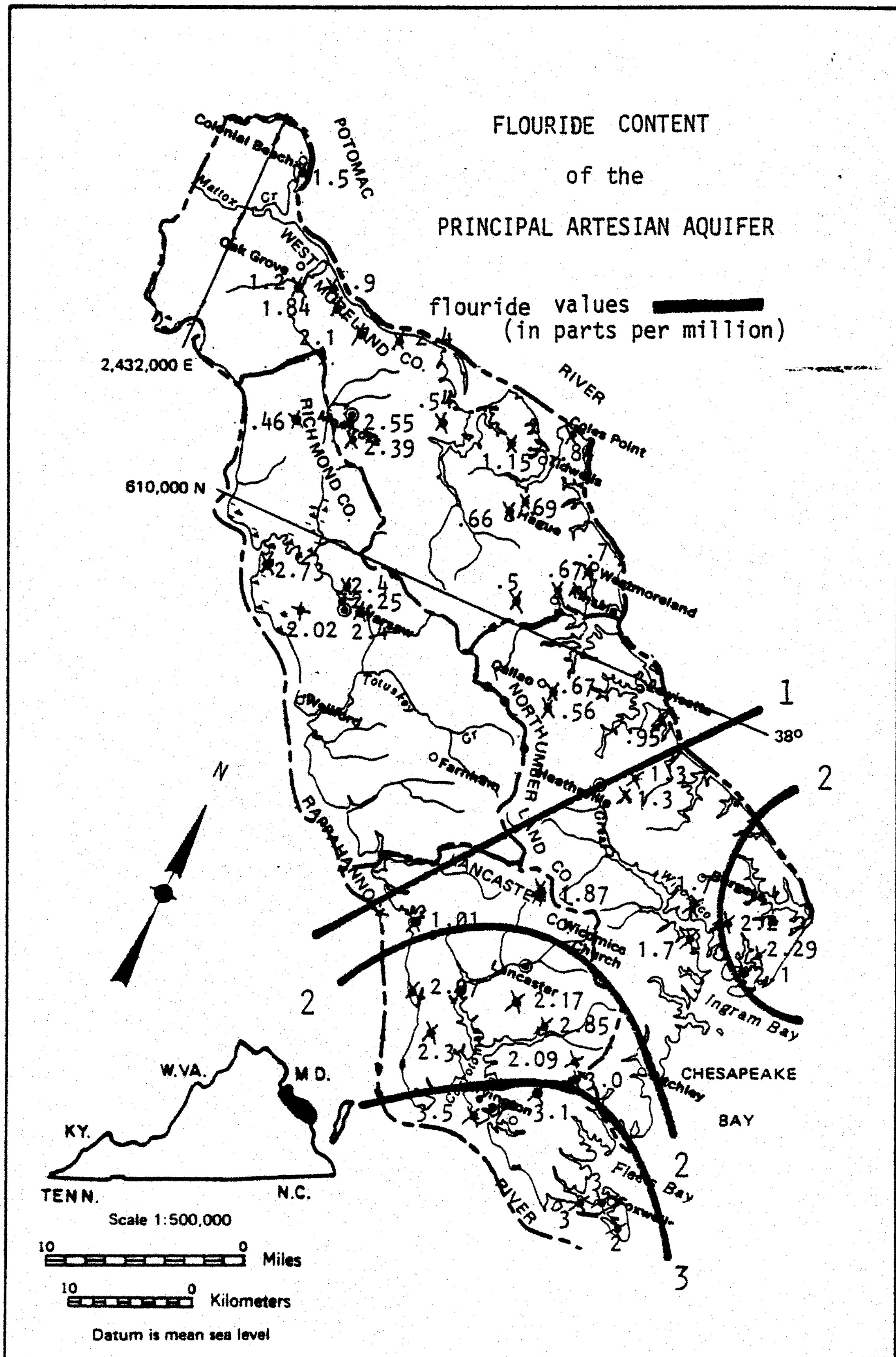

CHLORIDE CONTENT
of the
PRINCIPAL ARTESIAN AQUIFER
chloride values
(in parts per million)
POTOMAC
RIVER
Colonial Beach
WESTMORELAND CO.
RICHMOND CO.
NORTHUMBERLAND CO.
LANCASTER CO.
RAPPAHANNOCK
Coles Point
Hague
Westmoreland
Callao
Warsaw
Farnham
Heathsville
Burgess
Ingram Bay
CHESAPEAKE
BAY
2,432,000 E
810,000 N
38°
N
W.VA
MD.
KY
TENN
N.C.
10
100
Scale 1:500,000
Miles
Kilometers
Datum is mean sea level

Plate 12



Source: Virginia State Water Control Board

Plate 13



Source: Virginia State Water Control Board

Plate 14

TABLE 7

SUMMARY OF QUALITY ANALYSES OF NORTHERN NECK GROUNDWATER

AQUIFER		Depth	Cl	NO_3	F	Alka-linity	Hard-ness	Ca	Fe	K	Na	TDS/H
Water Table	Minimum	28	8.0	3.9	.01	17.0	32.0	6.0	.01	1.3	4.0	2.4
	Maximum	70	17.0	8.5	.10	26.0	51.0	14.0	.10	9.0	270.0	970.0
	Median	42	10.5	4.9	.05	21.0	32.5	11.5	.01	5.5	17.0	3.25
Upper Artesian Eastern Half	Minimum	305	1.0	.04	.48	29.0	8.0	5.0	.10	10.3	51.0	3.6
	Maximum	415	3.0	.13	3.5	547.0	72.0	16.0	.20	13.0	330.0	87.0
	Median	337	1.0	.05	.67	203.0	44.0	14.0	.10	12.0	105.5	4.4
Western Half	Minimum	208	1.0	.05	.29	133.0	12.0	8.0	.01	2.1	20.0	3.0
	Maximum	347	20.0	.18	2.12	304.0	72.0	18.0	.10	11.8	142.0	25.3
	Median	250	1.0	.05	.70	183.5	39.0	14.0	.50	11.1	71.0	7.9
Principal Artesian Eastern Half	Minimum	115	0.0	.013	.07	21.0	2.0	0.2	.01	1.4	9.0	3.8
	Maximum	809	169.0	2.22	3.35	690.0	53.0	12.5	1.5	23.0	430.0	258.0
	Median	670	2.5	0.085	2.3	371.5	6.0	2.0	.1	5.35	200.0	63.1
Western Half	Minimum	280	1.0	.05	.46	43.0	2.0	1.0	.01	2.5	23.0	2.9
	Maximum	854	4.0	.22	4.74	319.0	114.0	34.0	1.0	13.9	220.0	179.0
	Median	627	2.0	.05	2.1	264.0	10.0	2.0	.10	4.4	140.0	37.7

Source: Virginia State Water Control Board - TRO

Another significant chemical constituent of water found in the principal artesian aquifer is sodium. The sodium content of groundwater in the eastern zone has been found to be greater than 200 ppm (Plate 13). Restricted sodium intakes often are recommended for those people with various heart and blood problems. Accordingly, water containing 270 ppm or more should not be used for drinking water by those on a moderately-restricted sodium diet and water containing 20 ppm or more should not be used by those on a very-restricted sodium diet. The latter group of people would not be advised to utilize water from the principal artesian aquifer throughout the Northern Neck.

A high ratio (63.1) of total dissolved solids to hardness in the principal artesian aquifer is in contrast to a lower ratio (4.4) for the same parameters in the upper artesian aquifer (State Water Control Board, 1973). Fluoride concentrations are higher in the principal aquifer than they are in the water table and upper artesian aquifers; values range from 0.07 ppm to 4.74 ppm with an average of about 2.00 (Health Department standards are approximately 1.4 ppm, based on temperaturn correction). The fluoride values are slightly higher (Plate 14) in the eastern zone than further west, being 2 ppm to as much as 4.74 ppm.

Upper Artesian Aquifer. The upper artesian aquifer of the Northern Neck produces water of a moderately-soft type which is similar to the upper artesian aquifer in St. Marys County, Maryland. Major chemical parameter values are less than those of the water table aquifer (Table 7). Fluoride concentrations are generally less than those of the principal aquifer. The upper artesian aquifer is suitable for potable use throughout the Northern Neck for moderate amounts of supply.

Water Table Aquifer. Groundwater from the Calvert and Post-Miocene formations of the water table aquifer is generally satisfactory for domestic use. Either hardness or the presence of high concentrations of iron may make it locally unsatisfactory. Chlorides are generally in the potable range except in localized areas immediately adjacent to brackish, surface water bodies.

CHAPTER VI

GROUNDWATER DEVELOPMENT AND POTENTIAL

The water requirements for private, public and industrial purposes within the Northern Neck currently are being fulfilled by the abundant groundwater resources of the area. Several factors have contributed to the preference of groundwater development, as opposed to the utilization of surface-water resources. Some of these factors include: (1) development and treatment costs are approximately three to five times less for groundwater than for surface water, (2) the population distribution throughout the area is such as to favor the dispersed development of groundwater resources over construction of centralized, surface-water impoundments, and (3) industries within the area are located in a rural environment which lacks a central water supply of sufficient capacity to meet their needs.

Review of current data indicates that the potential for groundwater development is very large and that groundwater should meet adequately the needs of the area through the year 2020.

Groundwater Development

The most extensive groundwater development in the Northern Neck has been in the principal aquifer system. Approximately 88% of the total withdrawals are from this system. Although the groundwater in the Kilmarnock-Weems-Whitestone area and the Colonial Beach area probably has been developed more than any other area, groundwater in the Northern Neck thus far has not been noticeably overdeveloped. The largest industrial user is Zapata Haynie Corporation of Reedville, withdrawing 362,880 gallons per day (gpd) (1.374×10^6 liters per day). Approximately 971,000 gpd (3.675×10^6 L/day) of groundwater are used by numerous industries, including Zapata Haynie, and 944,000 gpd (3.675×10^6 L/day) by various public water suppliers (Industrial/Public Groundwater Use Survey). The remaining population not on public systems also must obtain its drinking water from wells of various depths. The total, estimated, usage of groundwater within the Northern Neck is 2,383,000 gpd (9.02×10^6 L/day) (CPRC Five-State Groundwater Report). Much of the industrial use is in the washing of seafood at local processing plants.

<u>Private Domestic Supplies</u>. Domestic or private systems serve much of the rural areas of the Northern Neck. A single-home dwelling commonly needs a well with a capacity of at least 1.5 to 6 gpm (5.6 to 22.7 L/min) to have a reliable water supply. This is not difficult to obtain throughout the Coastal Plain.

<u>Public Supplies</u>. As defined by the Virginia Department of Health and the Virginia State Water Control Board, a public water supply system is one which supplies water for human drinking or domestic purposes to more than 25 people or more than 15 connections. There are at least 30 of these systems throughout the Northern Neck, with withdrawals totalling approximately 1 MGD (3.785×10^6 L/day). These

systems vary from as little as 2,500 gpd to over 100,000 gpd. One of the most important, single considerations is groundwater quality, which is generally very good, and subsequently treatment costs are kept to a minimum. The number of wells is easily tailored to water needs.

Industrial Supplies. Data taken from Virginia State Water Control Board files indicate that there are at least 55 industrial users of groundwater in the Northern Neck, with withdrawals totalling approximately 1 MGD (3.785×10^6 L/day). This is an average of 18,000 gpd (68,130 L/day) per industry, or a requirement of 25 gpm (95 L/min).

Groundwater Potential

The groundwater potential of an area is simply the ability of that area to yield groundwater. Some type and amount of groundwater almost always can be obtained from some depth throughout the Coastal Plain of Virginia. Total groundwater usage in the Northern Neck is only approximately 2 MGD (7.57×10^6 L/day). This amount is assumed to be much less than the amount that conceivably could be used from wells that are developed now. In addition, an even larger amount could be developed in the future.

Problems and Limitations

Many of the problems associated with groundwater are in some way caused by man's use of, and influence on, the natural system. Movement of groundwater is relatively slow when compared to stream velocities. Therefore, both contamination and cones of depression tend to be localized. However, as the system is a fairly closed one, the effects are quite long-term and difficult to correct, once established.

Levels Decline. As discussed more extensively in Chapter V, the overall water levels in the Northern Neck have declined somewhat in recent years. No major cones of depression have developed in the Northern Neck as they have in the other areas of the Coastal Plain.

Quality Problems. The highly-mineralized content of the groundwater in the extreme southeastern part of the Northern Neck limits its use (See Chapter IV). Brackish groundwater may be found in the upper aquifers adjacent to brackish surface water bodies, especially on narrow peninsulas. Large well installations in the low-mineralized zone, within five miles or so of the highly mineralized zone, may tend to cause the highly-mineralized water to migrate inland. No such migration has been determined yet. Locations of observation wells to adequately detect chloride movement in the future are discussed in the following chapter.

Groundwater contamination refers to the introduction of a material foreign to the native groundwater that tends to reduce the water's usability. If the water is contaminated to the extent that it becomes nonpotable or unusable, the groundwater is said to be polluted. Sources of groundwater pollution are many and varied. Those which may be found within the Northern Neck are: septic tank systems, landfills, promiscuous dumps, sewage lagoons, industrial-waste lagoons, gasoline storage tanks, certain agricultural activities, highway de-icing salts, and irrigation-waste disposal sites. No detectable groundwater contamination was observed in the limited number of wells randomly sampled on the Northern Neck. Most of these above mentioned sources primarily would contribute to the contamination of the water table aquifer. As such, all domestic wells must be located at sufficient distances from any possible pollution sources in order to protect them from contamination. In a high density area, septic tank discharge may be one of the major sources of groundwater recharge and thereby cause pollution. High nitrates in the water could be indicative of this type of problem.

Landfills or dumps are possible contributors of a variety of contaminants. These contaminants could reach the groundwater by surface water percolating through them and producing leachate. In order for a sanitary landfill to avoid leaching, rainwater should be encouraged to run off rather than percolate through the fill material. Among the protective measures that can be taken are: (1) appropriate slope to the surface, (2) appropriate vegetative cover, and (3) impermeable soil cover. In any event, some water most likely will be absorbed by the landfill. In order to prevent surface water pollution, this liquid must not leach out, a very porous and permeable soil would favor this containment. However, in order to prevent groundwater pollution, this liquid must not be allowed to reach an aquifer. An impermeable layer would inhibit aquifer penetration. With these two opposing requirements it can be seen that the ideal soil conditions for a sanitary landfill would be difficult to find. Those ideal conditions are: a clay for the cover, many feet of sand for the liquid to filter through prior to reaching the water table aquifer and preferably a clay layer above the aquifer. Another protective method that has not yet been employed in the Northern Neck is to collect the leachate produced and treat it.

Spray irrigation waste-disposal sites present similar problems. They require several feet of permeable soil in order to absorb the liquid. Then additionally, in order to prevent the contaminants from polluting the groundwater, an impermeable layer is needed beneath the permeable layer. As can be gathered from this involved description, these ideal conditions seldom occur naturally. Unfortunately, for those concerned with the location of sanitary landfills, or irrigation waste disposal sites, these soil conditions are also ideal for septic tank systems. When these optimum conditions are found in the proximity of substantial human population, the area usually is zoned for residential construction. Thus, waste disposal sites are usually relegated to areas exhibiting less-than-favorable conditions.

Pollution of groundwater by petroleum products is a very serious problem that is relatively common. Usually an occurrence is confined to a small area and involves only one or two wells. This problem occurs primarily in the vicinity of gasoline service station facilities. Gasoline-storage tanks are not permanent fixtures and must be replaced periodically. Slow leaks can go unnoticed at a service station until a well becomes polluted or customers get water in the gasoline they purchase. The human threshold for the detection of gasoline can be as low as 0.005 ppm. An amount this small can render a water well unusable. The clean-up of subsurface, petroleum spills is difficult, costly, and often ineffective.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

This report provides a generalized picture of the groundwater resources of the Northern Neck portion of the Virginia Coastal Plain. The factors influencing the groundwater's quality, occurrence, availability, potential and development have been discussed. When considering the water resources of the area, the close inter-relationship between surface and groundwaters must be recognized. Some water that occurs on the surface eventually will become groundwater and vice-versa. Surface water provides recharge to the groundwater and, during periods of low surface water flows, groundwater supplements many surface water streams.

Conclusions

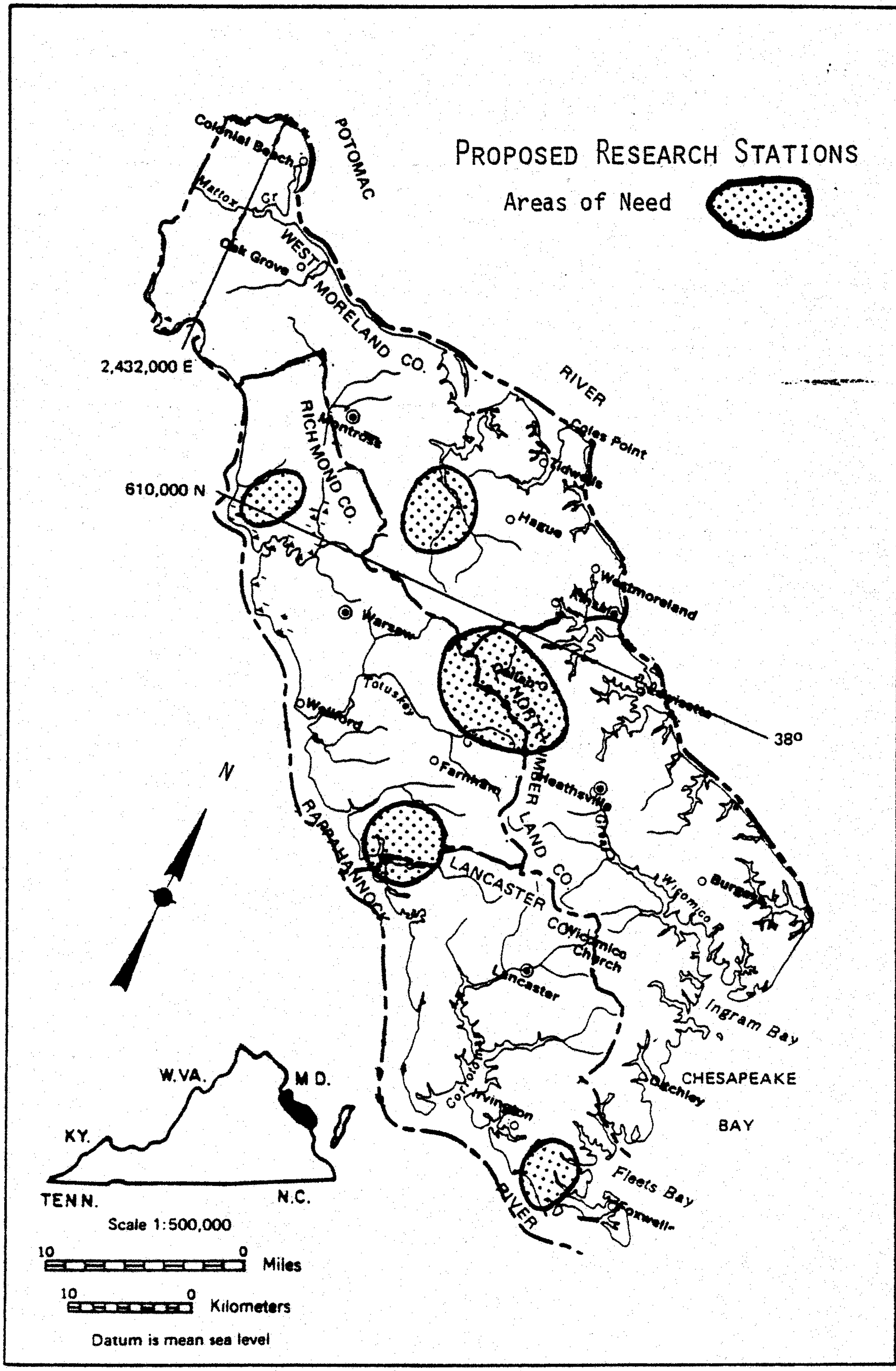
Current data on file suggest that groundwater in the Northern Neck can be developed more extensively than it is at present. Where 1 or 2 wells are not sufficient to supply water needs, development of a well field, utilizing several wells, spaced at 200-400 feet (61-122m) intervals, should provide an adequate water supply with a minimum of surface land area required for treatment facilities.

Groundwater levels have declined somewhat in recent years, although no excessive cones of depression have developed. No industrial or other relatively large user is known to interfere with another user. At present, man-made quality problems are not evident. However, the potential for problems exists at various industrial and other locations. Natural quality problems do exist in the parameters of sodium, fluorides, and chlorides in the southeast. Heavy, future withdrawals in this area may induce inland migration of brackish water from the high-chloride zone.

Recommendations

In order to access accurately the effects of waste-disposal sites on groundwater quality, monitoring wells should be established at each disposal site. This type of monitoring would not prevent all contamination, but it would assist in containing the contamination, and keeping it from becoming a large, widespread, and dangerous problem. Data obtained from the monitoring also would provide additional scientific information pertaining to the relationship of water movement through waste disposal sites. This information, in turn, further could assist scientists and engineers in developing additional waste-disposal site criteria.

A much more comprehensive and quantitative data base regarding groundwater is needed throughout the Northern Neck peninsula. At the present time, the elevations of the aquifers can be approximated only grossly due to the sparse data. With further research these elevations could be pinpointed more precisely. The most efficient method of obtaining this data is through the use of scientifically-constructed, research stations. A station is needed between Palmer and Whitestone in order to delineate the 250 ppm chloride (potable water) interface. Other areas where groundwater quality data especially is deficient and where research stations are recommended are; Morattico-Downings, Village-Luttrellville, Neenah, and Naylors (Plate 15). At all of these sites, the pilot hole should be logged by as many different techniques as possible so as to accurately pinpoint elevations of the aquifers in the area. At all of these sites, a pump test, with observation wells, needs to be performed on both the principal and upper artesian aquifers. This, in conjunction with the logs, would allow researchers to determine the capacity and potential of the aquifer. During the pump test a water sample should be taken and chemically analyzed. After these initial stations are in place, they should be monitored for water level and quality changes. Existing data, and the data obtained from the recommended observation wells, may be used to construct a computer model to predict water level declines and to assess groundwater availability. A comprehensive and continuous program of data collection is necessary for model verification.



Source: Virginia State Water Control Board

Plate 15

APPENDIX A

SUMMARY OF WATER WELL DATA FOR THE NORTHERN NECK

The computer printout on the following pages lists basic well data for wells in the Northern Neck. This printout is updated frequently to include information from new Water Well Completion Reports.

VIRGINIA STATE WATER CONTROL BOARD

BUREAU OF WATER CONTROL MANAGEMENT

SUMMARY OF WATER WELL DATA FOR LANCASTER COUNTY

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THE FOLLOWING LIST OF WELL DATA SUMMARIZES BASIC DATA OBTAINED FROM WATER WELL COMPLETION REPORTS WHICH ARE ON PERMANENT FILE IN THE OFFICES OF THE VIRGINIA STATE WATER CONTROL BOARD. ADDITIONAL INFORMATION FOR MANY OF THE WELLS IS AVAILABLE AND CAN BE OBTAINED BY CONTACTING THE APPROPRIATE REGIONAL OFFICE OR THE BUREAU OF WATER CONTROL MANAGEMENT AT THE AGENCY HEADQUARTERS IN RICHMOND.

************ EXPLANATION OF PARAMETERS ************

SWCB NO: STATE WATER CONTROL BOARD NUMBER - A SEQUENTIAL NUMBERING SYSTEM USED WITHIN A COUNTY; WHEN REFERRING TO A SPECIFIC WELL USE THIS NUMBER

OWNER AND/OR PLACE: IDENTIFIES ORIGINAL OR CURRENT WELL OWNER AND/OR LOCATION OF WELL

YEAR COMP: YEAR IN WHICH WELL CONSTRUCTION WAS COMPLETED

LOG: TYPE OF LOG ON FILE FOR WELL; D = DRILLERS, E = ELECTRIC, G = GEOLOGIC

ELEV: ELEVATION - MEASURED IN FEET ABOVE MEAN SEA LEVEL

TOTAL DEPTH: TOTAL DEPTH DRILLED, IN FEET, WITH RESPECT TO LAND SURFACE

BEDROCK: DEPTH TO BEDROCK, IN FEET, WITH RESPECT TO LAND SURFACE

CASING: MAXIMUM AND MINIMUM DIAMETER OF CASING, IN INCHES, USED IN WELL

DEVEL ZONE: DEVELOPED ZONE - INTERVALS, IN FEET, WHERE AQUIFERS TAPPED AND/OR SCREENED

AQUIFER: WATER-BEARING UNIT; ABBREVIATIONS USED INDICATE GEOLOGIC AGE OF UNIT AND ARE CONSISTENT WITH "GEOLOGIC MAP OF VIRGINIA" (DIVISION OF MINERAL RESOURCES - 1963)

STATIC LEVEL: DEPTH, IN FEET, TO WATER WITH RESPECT TO LAND SURFACE; MEASUREMENTS TAKEN WHEN WELL IS NOT PUMPED AND ARE GENERALLY THOSE RECORDED ON COMPLETION DATE

YIELD: REPORTED OR MEASURED PRODUCTION, IN GALLONS PER MINUTE

DRAWDOWN: DIFFERENCE, IN FEET, BETWEEN STATIC LEVEL AND PUMPING LEVEL; I.E., REPORTED OR MEASURED DROP, IN FEET, IN WATER LEVEL DUE TO PUMPING

SPFC CAPAC: SPECIFIC CAPACITY - YIELD PER UNIT OF DRAWDOWN EXPRESSED AS GALLONS PER MINUTE PER FOOT OF DRAWDOWN

HRS: HOURS - DURATION OF PUMP TEST, IN HOURS, FROM WHICH THE PRECEDING THREE ITEMS WERE DERIVED

USE: USE OF WATER OR WELL UNDER CONSIDERATION; DOM = DOMESTIC, PUB = PUBLIC, GOV = GOVERNMENT, IND = INDUSTRIAL, COM = COMMERCIAL, INS = INSTITUTIONAL, ABD = ABANDONED, DST = DESTROYED, IRR = IRRIGATION, RCH = ARTIFICIAL RECHARGE

V I R G I N I A   S T A T E   W A T E R   C O N T R O L   B O A R D

B U R E A U   O F   W A T E R   C O N T R O L   M A N A G E M E N T   DATE 08/05/78

SUMMARY OF WATER WELL DATA FOR LANCASTER COUNTY   PAGE 2

SWCB NO	OWNER AND/OR PLACE	YEAR COMP	LOG	ELEV	TOTAL DEPTH	BED-ROCK	CASING MAX	CASING MIN	DEVEL FROM	ZONE TO	AQUIFER	STATIC LEVEL	YIELD	DRAW DOWN	SPEC CAPAC	HRS	USE
1	TOWN OF KILMARNOCK	46	D		740		8		676	686	CRET	90	103	155	.66	36	PUB
2	E T NEMMON JR	56	D	10	582		4	2	531	566	CRET	9	70	118	.59	8	DOM
3	R T HERNDON	51	D		573		6	5	601	622	CRET	8	25	5	5.00		DOM
4	IRVINGTON PACKING CO	52	D		598		6	4	574	594	CRET		75	25	3.00		IND
5	WILLIAM HICKOK	52	D		720		6		650	670	CRET		35				DOM
6	WARWICK & ASHBURN	44	D		85		6		65	75	MIOCEN	20	30	25	1.20	9	DOM
7	W F MORGAN & SONS		D		120							4	8	41	.19	5	DST
8	W F MORGAN & SONS	44	D		335		6	5	312	329	EOCENE	20	21	45	.46	4	IND
9	R K WHALEY		D		830		3	2	689	699	CRET		50				DOM
10	OSCAR ASHBURN & SON	44	D		75		6	5	55	65	MIOCEN	5	15	40	.37	11	DOM
11	BARTON H CAMERON	53	D		634		6	4	608	634	CRET	10	10	242	.04	6	DOM
12	GANDRAL ERNEST	51	D		573		6	4	554	565	CRET	10	19	132	.14	11	DOM
13	HARDING SEAFOOD CO	44	D		101		6	5	69	79	MIOCEN	16	30	7	4.28	8	IND
14	FRANK C HATCH	35			520		3						12	9	1.33		DOM
15	OBSERVATION WELL #15		EG	85	716		4	2	706	716	PRINC		20				GOV
	KILMARNOCK																
16	STANDARD PRODUCTS COR	55	D		711		6		595	615	CRET	3	138	32	4.31	9	IND
17	IRVINGTON PACKING CO	44	D		76		6		52	62	MIOCEN	4	25	11	2.27	31	IND
18	E T NEMMON SR	51	D		605		8	6	562	581	CRET	25	30	94	.31		DOM
19	H A HARDING JR	52	D		110		4		70	80	MIOCEN	18	6			1	DOM
20	N N REAL ESTATE CORP	69			654		4	1	610	620	CRET	54	30	36	.83		PUB
	GRAND VILLA																
21	BELMONT DEV CO	68			590		4	2	512	587	CRET	54	40	36	1.11		PUB
	HERITAGE POINT																
22	IRVING OWINGS	69			664		4	2				55	75			6	PUB
	LAUREL POINT																
23	A R BEANE & SON	52	D	35	327		4	2				25	6	5	1.20	8	IND
24	W R PITTMAN & SONS	49		4	555		4	3	535	555	PRINC	4	18	7	2.57	10	IND
25	POLICE BOYS CAMP	50			635		4	1	613	635	CRET	2	10	15	.66	8	IND
26	J S WEEMS & SON	52	D		350		4		335	350			9			7	IND
27	TOWN OF KILMARNOCK	03		8	637		2						140				PUB
28	C P CROASDALE SEAFOOD	59		5	728		4	2				20					IND
29	TOWN OF KILMARNOCK	14		5	620		3						105				PUB
30	H V POINTER	70			696		4	1	658	668	CRET	12	40	38	1.05		DOM
31	LEWIS E BURKE	71			584		4	2	558	578	CRET	58	40	42	.95		PUB
32	TIDES INN	71	E	30	674		12	6	556	561	PRINC	45					ABD
									633	643							
33	WARWICK & ASHBURN				750												IND
34	WARWICK & ASHBURN	40			75												ABD
35	DOUGLAS & DICKENSON	55		2	668		4	2	648	668	PRINC						PUB
	FOXWELLS																
36	SYDNOR,EAST IRVINGTON																PUB
37	SYDNOR, IRVINGTON																PUB
38	DOUGLAS & DICKENSON																PUB
39	SYDNOR, LANCASTER C H																PUB
	TIDES INN SUB																

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SWCB NO	OWNER AND/OR PLACE	YEAR COMP	LOG	ELEV	TOTAL DEPTH	BED-ROCK	CASING MAX	CASING MIN	DEVEL FROM	ZONE TO	AQUIFER	STATIC LEVEL	YIELD	DRAW DOWN	SPEC CAPAC	HRS	USE
40	SYDNOR, LIVELY																PUB
41	DOUGLAS & DICKENSON																PUB
	NORTH WEEMS																
42	DOUGLAS & DICKENSON	56			636		6		616	636	PRINC	63	125	52	2.40		PUB
	WEEMS																
43	THE TIDES INN	72	DE		744		8		536	546	EOCENE	57	503	120	4.19	8	COM
									712	722							
44	LANCASTER CO SCHOOLS	72			805		6	3	647	667		92	100	125	.80		INS
45	DOUGLAS & DICKINSON	72	D		739		4	2	691	711		106	40	39	1.02	2	PUB
	CHURCHFIELDS																
46	BELMONT DEV CO	72	D		646		4	2	625	635	CRET	115	40	35	1.14	4	PUB
	HERITAGE POINT																
47	TIERRA FIN INC	73	D		690		6	3	670	690	CRET	28	100	40	2.50	24	PUB
48	MILLER, CORROTOMAN-	67			737		6	4	695	725	CRET	102	125	38	3.28	2	PUB
	BY-THE-BAY																
49	LACKERT	66			595		4	2	561	571	CRET	42	40	38	1.05	2	PUB
	BLACK STUMP WTR SY																
50	SYDNOR HYDRODYNAMICS	74	DE	30	675		10	6	555	570		49	295	89	3.31	24	PUB
51	HAYWOODS DOCK			25	325								12				DOM
52	C P SAUNDERS & SONS				486												DOM
53	LIVELY TOWN WELL				850												DOM
54	IRA D HINTON	66		101	802		4		770			104	40	33	1.21		DOM
55	LAWRENCE HARDING				30							22					DOM
56	J A DAVENPORT				26							17					DOM
57	R E V SEAFOOD CORP				600							19					DOM
58	THE HUMPHREYS RAILWAY			30	650												DOM
59	WILLIS MOUNTHEW				55												DOM
60	CORRFOMAN BAPTIST CH																DOM
61	J A CLARK	73	D		639		4	2	619	639		35	75	45	1.66	6	PUB
62	F W LACKERT	69			585		4		565	580	CRET	46	40	45	.88		DOM
63	DOUGLAS & DICKINSON	58			750		4	2									PUB
	COVE COLONY																
64	SYDNOR-LANCASTER C H				541		6	3									PUB
65	DOUGLAS & DICKINSON				305												PUB
	LANCASTER SHORES																
66	I OWINGS				755		4	2									PUB
	LAUREL POINT #1																
67	SYDNOR HYDRODYNAMICS	46	D		661		8		5000			35	85	50	1.70	24	PUB
	WHITESTONE BEACH																
68	JAMES CARTER	60	D		681		4					30	40	30	1.33	2	PUB
	TIDES INN CLUB #1																
69	DAVID LAY	75	D		70		30					50					DOM
70	VA DEPT OF HIWAYS			90	115		4					20					DOM
71	MARTIN WEAVER	76	D		360		4					21	75	10	7.50	3	DOM

V I R G I N I A   S T A T E   W A T E R   C O N T R O L   B O A R D

B U R E A U   O F   W A T E R   C O N T R O L   M A N A G E M E N T

DATE 08/05/78

SUMMARY OF WATER WELL DATA FOR LANCASTER COUNTY

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SWCB NO	OWNER AND/OR PLACE	YEAR COMP	LOG	ELEV	TOTAL DEPTH	BED-ROCK	CASING MAX	CASING MIN	DEVEL FROM	ZONE TO	AQUIFER	STATIC LEVEL	YIELD	DRAW DOWN	SPEC CAPAC	HRS	USE
72	G C DAWSON	76	D		670	645	4	4	2	644			40	35	1.14	3	PUB
73	REV JAMES R CARTER			20	60				50	60							DOM
74	G H LAWHORNE	62			687		4	2	663	683			2400	35	68.57		DOM
75	SCHECO INC	68			708		4	2	676	696			2400	13	184.61		DOM
76	CHARLES PARKER	76	D		400	80	4					75	50	20	2.50	3	PUB
77	LIVELY AIRPORT				283				265	275		6	3600	20	180.00		PUB
	0283 006026502																
78	IRVINGTON		E	35	580												PUB
79	W F SAUNDERS	64	E	25	742		4	2	727	742			20				PUB
80	TREAKLE CANNERY	41	E	3	666		4	3									PUB
81	MRS B A BURKE	67	E	2	674		4		658	678		7	40	40	1.00		PUB
82	CORROTOMAN BY THE BAY	77	E	50	689		6	3	659	679		73	165	99	1.66	48	PUB
83	KILMARNOCK, TOWN #3	77	DE		776		8	6	616	626		119	370	212	1.74	48	PUB
									738	768							
84	E J CONRAD & SONS												4				IND
85	CHESAPEAKE HERRING CO				600							21					IND
86	VIRGINIA SEAFOODS	70			800												IND
87	VIRGINIA SEAFOODS	49			750												IND

V I R G I N I A   S T A T E   W A T E R   C O N T R O L   B O A R D

B U R E A U   O F   W A T E R   C O N T R O L   M A N A G E M E N T

SUMMARY OF WATER WELL DATA FOR NORTHUMBERLAND COUNTY

****

THE FOLLOWING LIST OF WELL DATA SUMMARIZES BASIC DATA OBTAINED FROM WATER WELL COMPLETION REPORTS WHICH ARE ON PERMANENT FILE IN THE OFFICES OF THE VIRGINIA STATE WATER CONTROL BOARD. ADDITIONAL INFORMATION FOR MANY OF THE WELLS IS AVAILABLE AND CAN BE OBTAINED BY CONTACTING THE APPROPRIATE REGIONAL OFFICE OR THE BUREAU OF WATER CONTROL MANAGEMENT AT THE AGENCY HEADQUARTERS IN RICHMOND.

************ EXPLANATION OF PARAMETERS ************

SWCB NO: STATE WATER CONTROL BOARD NUMBER - A SEQUENTIAL NUMBERING SYSTEM USED WITHIN A COUNTY; WHEN REFERRING TO A SPECIFIC WELL USE THIS NUMBER

OWNER AND/OR PLACE: IDENTIFIES ORIGINAL OR CURRENT WELL OWNER AND/OR LOCATION OF WELL

YEAR COMP: YEAR IN WHICH WELL CONSTRUCTION WAS COMPLETED

LOG: TYPE OF LOG ON FILE FOR WELL; D = DRILLERS, E = ELECTRIC, G = GEOLOGIC

ELEV: ELEVATION - MEASURED IN FEET ABOVE MEAN SEA LEVEL

TOTAL DEPTH: TOTAL DEPTH DRILLED, IN FEET, WITH RESPECT TO LAND SURFACE

BEDROCK: DEPTH TO BEDROCK, IN FEET, WITH RESPECT TO LAND SURFACE

CASING: MAXIMUM AND MINIMUM DIAMETER OF CASING, IN INCHES, USED IN WELL

DEVEL ZONE: DEVELOPED ZONE - INTERVALS, IN FEET, WHERE AQUIFERS TAPPED AND/OR SCREENED

AQUIFER: WATER-BEARING UNIT; ABBREVIATIONS USED INDICATE GEOLOGIC AGE OF UNIT AND ARE CONSISTENT WITH "GEOLOGIC MAP OF VIRGINIA" (DIVISION OF MINERAL RESOURCES - 1963)

STATIC LEVEL: DEPTH, IN FEET, TO WATER WITH RESPECT TO LAND SURFACE; MEASUREMENTS TAKEN WHEN WELL IS NOT PUMPED AND ARE GENERALLY THOSE RECORDED ON COMPLETION DATE

YIELD: REPORTED OR MEASURED PRODUCTION, IN GALLONS PER MINUTE

DRAWDOWN: DIFFERENCF, IN FEET, BETWEEN STATIC LEVEL AND PUMPING LEVEL; I.E., REPORTED OR MEASURED DROP, IN FEET, IN WATER LEVEL DUE TO PUMPING

SPEC CAPAC: SPECIFIC CAPACITY - YIELD PER UNIT OF DRAWDOWN EXPRESSED AS GALLONS PER MINUTE PER FOOT OF DRAWDOWN

HRS: HOURS - DURATION OF PUMP TEST, IN HOURS, FROM WHICH THE PRECEDING THREE ITEMS WERE DERIVED

USE: USE OF WATER OR WELL UNDER CONSIDERATION; DOM = DOMESTIC, PUB = PUBLIC, GOV = GOVERNMENT, IND = INDUSTRIAL, COM = COMMERCIAL, INS = INSTITUTIONAL, ABD = ABANDONED, DST = DESTROYED, IRR = IRRIGATION, RCH = ARTIFICIAL RECHARGE

VIRGINIA STATE WATER CONTROL BOARD

BUREAU OF WATER CONTROL MANAGEMENT

DATE 08/05/78

SUMMARY OF WATER WELL DATA FOR NORTHUMBERLAND COUNTY

SWCB NO	OWNER AND/OR PLACE	YEAR COMP	LOG	ELEV	TOTAL DEPTH	BED-ROCK	CASING MAX	CASING MIN	DEVEL FROM	ZONE TO	AQUIFER	STATIC LEVEL	YIELD	DRAW DOWN	SPEC CAPAC	HRS	USE
1	EVERETT L GODDARD	68		400	400		4	2	231	400		100	40	40	1.00		IND
2	HAYNIE PRODUCTS CO	70			315		6	3	229	249			20	100	.20		IND
3	LEON GODDARD	67			738		4	2	712	732	LK	13	33	47	.70		PUB
4	G C DAWSON	68			658		4	2	617	637	LK	28	40	37	1.08		PUB
5	CLIFFORD LAWSON	70			698		4	2	633	653			40	40	1.00		DOM
6	SYDNOR-RIVER BEND EST	70	DE	100	730		6	4	646	666		73	60	33	1.81	7	DOM
7	S S HEADLY SEAFOOD #1				335		2										DOM
8	S S HEADLY SEAFOOD #2				335		4	2									DOM
9	SMITH SEAFOOD	71	D		718		4	2	688	708	LK	20	40	55	.72	6	IND
10	DOUGLAS & DICKENSON BAY QUARTER SHORES	64			620		6	3	596	616			150	78	2.14	4	PUB
11	DOUGLAS & DICKENSON BON HARBOURS																PUB
12	DOUGLAS & DICKENSON CHESAPEAKE BAY EST																PUB
13	SYDNOR, CALLAO																PUB
14	DITCHLEY	64		2	640		8	2	620	640		3	21	11	1.90	1	PUB
15	DOUGLAS & DICKENSON GLEBE POINT																PUB
16	SYDNOR, HEATHSVILLE	46			448		8		438	448		87	50	70	.71	24	PUB
17	LEWISETTA																PUB
18	LOCKSLEY HALL																PUB
19	LOCKSLEY HALL																PUB
20	SYDNOR, LOTTSBURG																PUB
21	DOUGLAS & DICKENSON MIDWAY	65			804		4	2	655	660		85	34	45	.75	2	PUB
22	DOUGLAS & DICKENSON SHERWOOD FOREST	65			792		6	3	671	681		7	150	53	2.83	2	PUB
23	DOUGLAS & DICKENSON WICOMICO CHURCH	65			714		4	2	672	677		90	16	110	.14	2	PUB
24	REEDVILLE																PUB
25	E I DUPONT				580		5						160				PUB
26	HAYNIE PRODUCTS INC	72	DE	14	809		8	6	685	710		23	503	32	15.71		IND
27	DOUGLAS & DICKENSON WICOMICO RIDGE SUB	72	D		723		4	2	695	715	LK	88	40	37	1.08	72	PUB
28	STANDARD PRODUCTS INC	73	DE	10	759		18	8	649 725	654 740	LK	20	510	89	5.73	24	IND
29	HAYNIE PRODUCTS INC				600		6										IND
30	J D HINTON	50			690		4	3	513	527	CRET	65	10	70	.14	9	IND
31	J A KECK				111							15	10	20	.50	3	IND
32	NORTHUMBLND PLANTAIN	66			799		6	3	767	787	CRET		150	60	2.50	3	IND
33	LOCKSLEY HALL ESTATES	64			777		4	2	756	776	CRET	6	40	29	1.37	2	PUB
34	NORTHUMBLND CIVIC CEN	64			646		6	3	616	639	CRET	30	150	60	2.50	3	PUB
35	G C DAWSON	64			680		4	2	658	678	CRET	7	60	53	1.13	2	PUB

V I R G I N I A   S T A T E   W A T E R   C O N T R O L   B O A R D

B U R E A U   O F   W A T E R   C O N T R O L   M A N A G E M E N T

SUMMARY OF WATER WELL DATA FOR NORTHUMBERLAND COUNTY

SWCB NO	OWNER AND/OR PLACE	YEAR COMP	LOG	ELEV	TOTAL DEPTH	BED-ROCK	CASING MAX	CASING MIN	DEVEL FROM	ZONE TO	AQUIFER	STATIC LEVEL	YIELD	DRAW DOWN	SPEC CAPAC	HRS	USE
36	E L GODDARD	63			659		4	2	540	550	CRET		50	30	1.66	2	PUB
37	FRED W HAISLIP	67			673		4	2	655	670	CRET	8	40	32	1.25	2	PUB
38	BLUNDEN & HINTON #2	74	D		7250		4					340	75			6	PUB
39	KRENTZ MARINA				285							2					PUB
40	CALLAO ELEM SCHOOL																PUB
41	E E GOODARD				400		4										PUB
42	FLEETON																PUB
43	INDIAN CREEK YACHT CL	58			635		6						150	50	3.00	4	PUB
41	E L GOODARD				400		4										PUB
42	FLEETON																PUB
43	INDIAN CREEK YACHT CL	58			635		6						150	50	3.00	4	PUB
44	SHERWOOD FOREST-AM CT	76	E	50	804		6	3	670	764	PRIN	22	127	251	.50	48	PUB
45	CAPT. A H COWART	75			315			2	298	308		5	10	25	.40		DOM
46	AMERICAN CENTRAL CORP	76			649		6	3	623	643		28	213	92	2.31	48	DOM
47	REEDVILLE&TIBITHA SEW	76			725		4	2	694	714		27	240				DOM
48	DOUGLAS-LEE DALE SHOR				736		4	2	730	736	PRIN		40	60	.66		DOM
49	CHARLES ROBINSON	75	D		420		4		360	420		28	75	8	9.37	3	DOM
50	WILLIAM ANDERSON	76	D		380	110	4	4					50	10	5.00	2	DOM
51	HORACE WASHINGTON	73		101	70		36		65	70							DOM
52	SAMUEL T SEWELL	76			351		2		336	346		16	500	30	16.66		DOM
53	PATRICA ANN JONES	76			715		4	2	696	706		93	40	130	.30		DOM
54	STEVE BARTON	76			403		4	2	386	396		72	30	100	.30		DOM
55	OTIS CANNON CROWTHER	76			710		4	2	690	700		96					DOM
56	JOHN B LOWRY	76			744		4	2	694	734		104	40	140	.28		DOM
57	E MORRIS FALLIN	75			52		30		25	30		45					DOM
58	E L GODDARD	76			755		6	4	740	755		21	75			8	DOM
59	LANE DITCHLEY		EG	2	426												DOM
60	F W HANES		NE	5	693												DOM
61	RUSSELL GARNER	76		112	415		4	2	368	378		12	30	150	.20		DOM
63	NRTHUMRRLND SCHOOL BD	77	D		692		4	2	663	683		100		50			DOM
64	DOUGLAS DICKENSON	77	D		631		4		604	625		33	64	85	.75	48	DOM
65	NORTHUMBERLAND CO	76	D		725		4		694	714		27	40	33	1.21		DOM
66	GORDON EVANS, KOA	76			682		2		655	675		16	40	41	.97		DOM
67	INDIAN CR. SYSTEM	77			631				604	625		[illegible]	64	85	.75		DOM
68	WALT ROBBINS	77			834		4	2	778	798		11	52	61	.85	48	PUB
69	FAIRFIELDS ELE SCHOOL												2				INS
70	NORTHUMBERLAND H S	63			700								4				INS
71	NORTHUMBERLAND JHS	56			625								3				INS
72	LAKE PACKING CO #3	00			330												IND
73	LAKE PACKING CO #2	48			330												IND
74	LAKE PACKING CO #1	60			660												IND

VIRGINIA STATE WATER CONTROL BOARD

BUREAU OF WATER CONTROL MANAGEMENT

SUMMARY OF WATER WELL DATA FOR WESTMORELAND COUNTY

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THE FOLLOWING LIST OF WELL DATA SUMMARIZES BASIC DATA OBTAINED FROM WATER WELL COMPLETION REPORTS WHICH ARE ON PERMANENT FILE IN THE OFFICES OF THE VIRGINIA STATE WATER CONTROL BOARD. ADDITIONAL INFORMATION FOR MANY OF THE WELLS IS AVAILABLE AND CAN BE OBTAINED BY CONTACTING THE APPROPRIATE REGIONAL OFFICE OR THE BUREAU OF WATER CONTROL MANAGEMENT AT THE AGENCY HEADQUARTERS IN RICHMOND.

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SUMMARY OF WATER WELL DATA FOR WESTMORELAND COUNTY

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SWCB NO	OWNER AND/OR PLACE	YEAR COMP	LOG	ELEV	TOTAL DEPTH	BED-ROCK	CASING MAX	CASING MIN	DEVEL FROM	ZONE TO	AQUIFER	STATIC LEVEL	YIELD	DRAW DOWN	SPEC CAPAC	HRS	USE
1	MONTROSS LUMBER CO	53	D		290		6	4	268	278		110	35	80	.43	7	IND
2	NATIONAL PARK SERV #1	65	DE		667		6		451	466		19	57	15	3.80	12	GOV
3	NATIONAL PARK SERVICE	31			310		5					9	25	83	.30		GOV
4	NATIONAL PARK SERVICE	48	D		720		10		658	666		130	90	68	1.32		GOV
5	DOUGLAS & DICKENSON GLEBE HARBOR SUB	68			468		6	3	391	411		18	82	108	.75		PUB
6	A T QUICK	45	D		114		6	5	99	109		10	21	78	.26	8	DOM
7	TEMPLEMAN SCHOOL	54	D		303		6		263	288		111	33	104	.31	7	INS
8	OAK GROVE SCHOOL	48	D		330		6	3	236	248		48	27	35	.77	19	INS
9	WESTMORELAND ELEM SCH	57	D		784		6		590	620		124	91	136	.66	12	INS
10	WASHINGTON DIST E SCH	52	D		408		6		363	378		24	17	176	.09	18	INS
11	COPLE SCHOOL	51	D		345		6	5	312	322			33			12	INS
12	SANFORD CANNING CO.	69	DE		300		6	4	211	221		10	110	69	1.59	4	IND
13	AMERICAN CENTRAL CORP	69			595		6	3	574	589		145	100	105	.95		PUB
14	AMERICAN CENTRAL CORP	69			603		6	3	568	578		15	100	185	.54		PUB
15	AMERICAN CENTRAL CORP	69			653		6	3	589	599		120	100	80	1.25		PUB
16	OBSERVATION WELL 16 MONTROSS	66	D	149	641		4	2	608	628		135	10				GOV
17	SCOVILL	66	DE	145	817		20	8	430	461		141	844	148	5.70	28	IND
									546	554							
									643	653							
18	COLONIAL BEACH	46	D		654												PUB
19	BELRUM OYSTER CO	66	E		329		5	4	198	208		1	20	4	5.00	5	IND
20	PLACID BAY ESTATES	73			300		7	5	240	260		18	55	4	13.75	72	PUB
21	MRS DOROTHY STAFFA	69			381		4	2	368	378		67	30	43	.69		COM
22	J F FOXWELL, JR	70			370		4	2	326	366		13	60				COM
23	GLENDALE ASSOCIATES CABIN POINT SUB	72	DE		780		10	8	340	360		15	554	132	4.19	24	PUB
									570	582							
24	GLENDALE ASSOCIATES CABIN POINT SUB	72	DE		748		10	8	342	362		17	800	62	12.90	24	PUB
									568	580							
25	IRA MUSE	71	D		357		4	2	338	353		4	40	40	1.00	2	PUB
26	GEORGE ROBBERECHT	71			359		4	2	329	349		4	40	36	1.11		IND
27	JOHN BALL	70			207		2		185	195		8	10	22	.45		IND
28	WILLIAM BARRACK	71			433		4	2	398	418		18	40	32	1.25		PUB
29	POND-A-RIVER	72			407		6	2	370	400		19	50	56	2.67		COM
30	NATIONAL PARK SERV	72	D		360		6		266	271		29	50	75	.66	8	GOV
									306	321							
31	ALLENS OYSTER HOUSE				240		4					12					IND
32	DAIGER BROS SEAFOOD	67			230		4						60				IND
33	NORTHN NECK COCA-COLA	37			668		6		650	665		120	100	130	.76	24	IND
34	DEANS SEAFOOD	58			533		4	2									IND
35	A L TRADER OYSTER HSE	62			240		4					18	35	72	.48		IND

VIRGINIA STATE WATER CONTROL BOARD

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SUMMARY OF WATER WELL DATA FOR WESTMORELAND COUNTY

SWCB NO	OWNER AND/OR PLACE	YEAR COMP	LOG	ELEV	TOTAL DEPTH	BED-ROCK	CASING MAX	CASING MIN	DEVEL FROM	ZONE TO	AQUIFER	STATIC LEVEL	YIELD	DRAW DOWN	SPEC CAPAC	HRS	USE
36	HORNERS BEACH WTR SUP				300		4					10	40	30	1.33		PUB
37	HORNERS BEACH WTR SUP				270		4					12	40	28	1.42		PUB
38	SYDNOR, KINSALE	46		70	280							53	130	25	5.20		PUB
39	L L CURLEY	62			880								100				PUB
	MONROE BAY ESTATES																
40	TOWN OF MONTROSS	36	G		560		6	4	535	541		132	15			10	PUB
41	BERKLEY BEACH																PUB
42	COLONIAL BEACH	53	D		824		8		794	821			125			67	PUB
43	COLONIAL BEACH				816		8		736	816							PUB
44	PLACID BAY ESTATES																PUB
45	POTOMAC SHORES																PUB
46	POTOMAC SHORES																PUB
47	SANDY POINT																PUB
48	RESEARCH HOMES INC	72	D		330		6		226	236		163	50	260	.19	24	PUB
	CROWS NEST HARBOR																
49	WESTMORELAND STATE PK				600												GOV
50	ALLENS OYSTER HOUSE				260												IND
51	DEANS SEAFOOD				210												IND
52	HARDING SEAFOOD INC				230												IND
53	TOWN OF MONTROSS	65			702		8	6	549	554		133	123	92	1.33	12	PUB
54	L L CURLEY	73	D		460		6	3	427	447		24	125	56	2.23	3	PUB
55	WILKINS WATER CO.	73	D		389		6		190	220		13	150	160	.93	48	PUB
	VERNON WILKINS																
56	GORDON HORNER	74	D		329		4	2	284	294		29	30	81	.37	2	PUB
57	NATIONAL PARK SERV #4	74	DE	20	814		6		394	409		23	150	25	6.00	24	PUB
	GEO WASH BIRTHPLACE																
58	VA STATE DEPT HIWAYS	74	D	18	401		4	2	383	393		25					PUB
	POTOMAC MILLS HDQS																
59	L WARNER PARKER				40							32					PUB
60	G F KOTAPEC				280		2					8					PUB
61	E A JENKINS JR						2										PUB
62	EBENEZER UNITED				500							290					PUB
	METHODIST CHURCH																
63	WHITE CHURCH ON 640											39					PUB
64	JOHN W WELCH FUNERAL	66			650		4		618			138					DOM
65	DARL CONCRETE & CONST	67			890		4		844			24					DOM
66	FRED FAIRFAX	75	D		420		4					129	50	12	4.16	2	DOM
72	JAMES E WILSON	75	D		260		4					18	75	10	7.50	3	DOM
73	JOHN BIBBINS	75	D		260		4					19	50	6	8.33	3	DOM
74	JERRY V SHOAF	75	D		240		4					19	75	6	12.50	3	DOM
75	EDDIE BWANE	75	D		420		4					118	75	6	12.50	4	DOM
76	JACK SMITH	75	D		260		4					41	75	2	37.50	3	DOM
77	MRS G W GRIGSBY	75	D		260		4					18	75	3	25.00		DOM
78	W S TERRELL	75	D		240		4					10	75	6	12.50	3	DOM

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79	KWIN CONNALLY	75	D		240		4					14	75	6	12.50	3	DOM
80	BUD TUTWILEER	75	D		240		4					18	75	5	15.00	3	DOM
81	RANDOLPH SMITH	75	D		260		4					12	75	5	15.00	3	DOM
82	C H COLE	75	D		240		4					16	75	6	12.50	3	DOM
83	JAMES MOZINGO	75	D		233		4		222	232			40	50	.80	1	DOM
84	JENKINS & SON SEAFOOD	75	D		265		4		254	264			40	50	.80	1	DOM
85	STANLEY DIXONS OYSTER	75	D		240		4					13	75	6	12.50	3	DOM
86	RAY B SMILSER	75	D		240		4					13	75	8	9.37	3	DOM
87	HENDRIX OYSTER CO	75	D		340		4					112	50	8	6.25	3	DOM
88	MR G O PADDY	75	D		240		4					16	75	8	9.37	3	DOM
89	JAMES A HINTON	75	D		280		4					67	75	7	10.71	3	DOM
90	JEAN & J B THOMPSON	75	D		280		4					70	50	7	7.14	3	DOM
91	VA DEPT OF HIGHWAYS			100	32		26					19					DOM
92	MCKENNEY'S OYSTER HS	76	D		240		4	2	215	225		24	75	5	15.00	2	DOM
93	W H FREEMAN	75	D		260		4		231	241							DOM
94	HELEN BAILEY	76	D		240		4					10	75	7	10.71	3	DOM
95	MARVIN BRANN	76	D		220		4					10	75	5	15.00	2	DOM
96	CHANDLER CHEVROLET	76	D		360		4		329	339		112	75	5	15.00	4	COM
97	JOHN SIMPSON	75	D		220		4					18	75	6	12.50	3	DOM
98	ELVIN VERNON	75	D		240		4						75	7	10.71	3	DOM
99	JAMES R RUBY	76	D		240		4					12	75	6	12.50	2	DOM
100	JIM HART	76	D		240		4					16	75	6	12.50	2	DOM
101	O J MCCAULEY	76	D		240		4					18	75	10	7.50	3	DOM
102	W E MUNDYY	76	D		240		4					18	75	10	7.50	3	DOM
103	JOHN R BOWER JR	76	D		340		4					122	50	10	5.00	3	DOM
105	THOMAS ARNEST	76	D	124	340	293	4	2	320	330		124	20	76	.26		PUB
106	STEVE BRYANT	76	D		240	20	4	4					75	10	7.50		PUB
107	FRANCES E JENKINS	76	D		240	3	6	3					75	10	7.50		PUB
108	WESTMORELAND SUNOCO	64		130	30												PUB
109	STUANTE CARYS	76	D		360	30	4					20	75	10	7.50	1	DOM
110	HESTONYLA NUSHAY	76			400		4					60	15	100	.15	6	PUB
112	B W GOODEN	76			240		4					17	100	8	12.50	3	DOM
113	CHARLES BAYTON	73		70	652		4	2	617	637		60	40	40	1.00		DOM
114	LEWIS W. ENGLISH	75		125	343		4	2	332	342		123	25	37	.67		DOM
115	ARNOLD USUAL	76		16	208		2		196	206		21	7	9	.77		DOM
116	CARMEL METHODIST CH	66		135	347		4	2	327	342		105	60	45	1.33		DOM
117	WARREN PERRY	72		11	392		4	2	377	387		14	60	36	1.66		DOM
118	JACK J JONES	74		20	189		2		178	188		13	5	17	.29		DOM
119	GARNETT REAMY	76		17	223		2		210	220		19	5	31	.16		DOM
120	WILLIAM PALACIA	76		20	235		2		220	230		21	5	29	.17		DOM
121	ROBERT D MOYE	76		20	248		2		233	243		19	7	16	.43		DOM
122	HENRY JACKSON	76		11	191		2		173	183		6	5	29	.17		DOM
123	N W GARRETT	76			243		2		223	233		18		5			DOM
124	H H CANADAY	76			240		2		225	235		21	5				DOM

SWCB NO	OWNER AND/OR PLACE	YEAR COMP	LOG	ELEV	TOTAL DEPTH	BED-ROCK	CASING MAX	CASING MIN	DEVEL FROM	ZONE TO	AQUIFER	STATIC LEVEL	YIELD	DRAW DOWN	SPEC CAPAC	HRS	USE
125	ROY COFFEY			21	245		2		220	230		16	5				DOM
126	RALPH MERRILL		D	10	382		4	2	320	380		16	40	44	.90		DOM
127	DENNIS BARTLETT	76	D	46	228		2		208	218		45					DOM
128	WALLACE W ATWOOD JR				682		4		667	682							DOM
129	WESTMORELAND STATE PA	77	DE		490		6	4	384	478		139	55	83	.66	48	PUB
130	DOUGLAS & DICKINSON	73			627							139	125				PUB
131	HAROLD AUSTIN				628		4	2	613	623		138	40				PUB
132	HISTORYLAND PLAYG INC	77	D		510		.8		365	375		100	90	375	.24	48	DOM
133	USGS WATER RESOURCES OAK GROVE TEST	76	E		1349		10	8	1338	1343		170					DOM
134	VA DEPT OF HIWAY FDBG	77	D		305		4	2	278	288		88	29	58	.50		DOM
135	WESTMORELAND ST. PARK	77	ED		565		6	4	384	404		140	55	83	.66		DOM
136	WESTMORLND CO BD SUPR	77	E		500		12	6	465	480		135	75	37	2.02	48	PUB
137	BLANCHE R HAMNILL	77	D		55							40	4				DOM
138	CHARLES F STEVENS	78	D		51							35	4				DOM

VIRGINIA STATE WATER CONTROL BOARD

BUREAU OF WATER CONTROL MANAGEMENT

SUMMARY OF WATER WELL DATA FOR RICHMOND COUNTY

****

THE FOLLOWING LIST OF WELL DATA SUMMARIZES BASIC DATA OBTAINED FROM WATER WELL COMPLETION REPORTS WHICH ARE ON PERMANENT FILE IN THE OFFICES OF THE VIRGINIA STATE WATER CONTROL BOARD. ADDITIONAL INFORMATION FOR MANY OF THE WELLS IS AVAILABLE AND CAN BE OBTAINED BY CONTACTING THE APPROPRIATE REGIONAL OFFICE OR THE BUREAU OF WATER CONTROL MANAGEMENT AT THE AGENCY HEADQUARTERS IN RICHMOND.

************ EXPLANATION OF PARAMETERS ************

SWCB NO: STATE WATER CONTROL BOARD NUMBER - A SEQUENTIAL NUMBERING SYSTEM USED WITHIN A COUNTY; WHEN REFERRING TO A SPECIFIC WELL USE THIS NUMBER

OWNER AND/OR PLACE: IDENTIFIES ORIGINAL OR CURRENT WELL OWNER AND/OR LOCATION OF WELL

YEAR COMP: YEAR IN WHICH WELL CONSTRUCTION WAS COMPLETED

LOG: TYPE OF LOG ON FILE FOR WELL; D = DRILLERS, E = ELECTRIC, G = GEOLOGIC

ELEV: ELEVATION - MEASURED IN FEET ABOVE MEAN SEA LEVEL

TOTAL DEPTH: TOTAL DEPTH DRILLED, IN FEET, WITH RESPECT TO LAND SURFACE

BEDROCK: DEPTH TO BEDROCK, IN FEET, WITH RESPECT TO LAND SURFACE

CASING: MAXIMUM AND MINIMUM DIAMETER OF CASING, IN INCHES, USED IN WELL

DEVEL ZONE: DEVELOPED ZONE - INTERVALS, IN FEET, WHERE AQUIFERS TAPPED AND/OR SCREENED

AQUIFER: WATER-BEARING UNIT; ABBREVIATIONS USED INDICATE GEOLOGIC AGE OF UNIT AND ARE CONSISTENT WITH "GEOLOGIC MAP OF VIRGINIA" (DIVISION OF MINERAL RESOURCES - 1963)

STATIC LEVEL: DEPTH, IN FEET, TO WATER WITH RESPECT TO LAND SURFACE; MEASUREMENTS TAKEN WHEN WELL IS NOT PUMPED AND ARE GENERALLY THOSE RECORDED ON COMPLETION DATE

YIELD: REPORTED OR MEASURED PRODUCTION, IN GALLONS PER MINUTE

DRAWDOWN: DIFFERENCE, IN FEET, BETWEEN STATIC LEVEL AND PUMPING LEVEL; I.E., REPORTED OR MEASURED DROP, IN FEET, IN WATER LEVEL DUE TO PUMPING

SPEC CAPAC: SPECIFIC CAPACITY - YIELD PER UNIT OF DRAWDOWN EXPRESSED AS GALLONS PER MINUTE PER FOOT OF DRAWDOWN

HRS: HOURS - DURATION OF PUMP TEST, IN HOURS, FROM WHICH THE PRECEDING THREE ITEMS WERE DERIVED

USE: USE OF WATER OR WELL UNDER CONSIDERATION; DOM = DOMESTIC, PUB = PUBLIC, GOV = GOVERNMENT, IND = INDUSTRIAL, COM = COMMERCIAL, INS = INSTITUTIONAL, ABD = ABANDONED, DST = DESTROYED, IRR = IRRIGATION, RCH = ARTIFICIAL RECHARGE

SWCB NO	OWNER AND/OR PLACE	YEAR COMP	LOG	ELEV	TOTAL DEPTH	BED-ROCK	CASING MAX	CASING MIN	DEVEL FROM	ZONE TO	AQUIFER	STATIC LEVEL	YIELD	DRAW DOWN	SPEC CAPAC	HRS	USE
1	J G AYLOR			5	250												DOM
2	NORMAN DART			5	250												DOM
3	NORMAN DART			5	360												DOM
4	FARNHAM SCHOOL	51	D		373		6	4	331	341		104	50	23	2.17	2	INS
5	RICHMOND CO ELEM SCH	52	D		392		6		325	335			30			7	INS
6	TOWN OF WARSAW	49	D	143	653		8		618	653	LK	119	211	99	2.13	7	PUB
7	TOWN OF WARSAW	62	DE	143	702		8	6	622	632	LK	117	503	163	3.08	24	PUB
8	PLANNED NEIGHBORHOODS	72			358		4	2	334	354		86	40	130	.30		PUB
9	VEPCO	71	D		339		4	2	317	337		105	35	22	1.59	24	IND
10	DOUGLAS & DICKINSON LUTTRELLVILLE				790		4	2				147	30	22	1.36	2	PUB
11	STRAUSS, LEVI & CO	54			750							200	55				IND
12	FIELD UNIT #17	57			750		6										GOV
13	WOOD PRESERVES INC	61			706		4	2									IND
14	VA EXPERIMENTAL FARM		E	133	520												GOV
15	LEVI STRAUSS & CO	54	D		750		8	6	637	658	LK	132	235	35	6.71	24	IND
16	DOUGLAS & DICKENSON TOTUSKEY SUB	72	D		700		4	2	677	697	LK	124	40	36	1.11	48	PUB
17	FARNHAM BAPTIST CHUR.				50							30					PUB
18	MANAKIN BAPTIST CHUR.				50							22					PUB
19	DAVID M FRIDAY				50							20					PUB
20	SHIRLEY JACKSON				80							50					PUB
21	G A BROWN	66			458								40	28	1.42		COM
22	G A BROWN						4						40	31	1.29		DOM
24	JOSEPH GALLAGHER	75	D		280		4					19	50	10	5.00	3	DOM
25	DURWOOD OBIER	75	D		400							76	50	6	8.33	3	DOM
26	HAROLD M GALLAGHER												166				DOM
28	JOSEPH B FALLIN	76	D		380		4	2	340	350		120	75	10	7.50	2	DOM
29	LAWRENCE JANKINE	76	D		220		4					19	75	10	7.50	2	DOM
30	J D DAWSON, JR	76			374		4					106	3000				DOM
31	G L PACKETT	76			399		4					112	1800				DOM
32	ALLEN CROWDER	76			399		4					126	2250				DOM
33	E E HINTON	76			376		4					97	2400				DOM
34	ROY A RIGTERINK	76			302		2					29	300				DOM
65	B C SCULTHOPE	76			250		2					1	600				DOM
36	S M HULL	76			250		2					7	600				DOM
37	MARY BARBER	76			301		4					89	2000				DOM
38	W H MACKEY	76			312		4					114	2000				DOM
39	ROBERT W LOWERY, JR	76			230		2					38	300				DOM
40	NORMAN A DART	40			854												DOM
42	JAMES SHELTON	74			233				221	231		15	500				DOM
43	ROBERT W LOWERY	76			230							35	300				DOM
44	CONOCO	74		30	125												DOM
41	BARNEY LANIER	72			285												DOM

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SWCB NO	OWNER AND/OR PLACE	YEAR COMP	LOG	ELEV	TOTAL DEPTH	BED-ROCK	CASING MAX MIN	DEVEL FROM	ZONE TO	AQUIFER	STATIC LEVEL	YIELD	DRAW DOWN	SPEC CAPAC	HRS	USE

APPENDIX B

SUMMARY OF WELL POTENTIAL DATA FOR

THE NORTHERN NECK

Appendix B contains well potential data on the Northern Neck. Well numbers can be cross-referenced to Appendix A. The data listed in Appendix B includes:

State Water Control Board Number
Owner
Screen depth
Aquifer
Diameter (in.) of well casing
Test yield (gpm)
Drawdown (ft.)
Specific capacity (gpm/ft)
Log type
Corrected specific capacity-corrected for partial penetration
Duration of pump tests (hr)
Approximate transmissivity (gpd/ft)

WELL POTENTIAL DATA FOR LANCASTER COUNTY

SWCB Number	Owner	Screen. Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Log Type	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpd/ft)
151-6	Warwick & Ashburn	65-75	Water Table	6X4.5	30	25	1.2	D	1.2	9	2,000
151-8	W.F. Morgan & Sons	312-329	UAA	6X4.5	21.43	45	0.5	D	0.5	3.5	-
151-17	Irvington Packing	52.75-62	Water Table	6X4.5	25	11	2.3	D	2.3	31	4,000
151-41	North Weems	558-568 631-641	PAA	6X3	100	45	2.2	-	4.4	-	-
151-42	Weems	616-636	PAA	6X3	125	52	2.4	-	4.8	-	-
151-44	Lancaster High School	647-667 783-805	PAA	6X3.5	100	33	3.0	D	4.3	-	-
151-45	Churchfield Subdivision	691-711	PAA	4X2	40	39	1.0	D	1.8	2	-
151-47	Tierra Fin	670-690	PAA	6X3	100	40	2.5	D	4.4	24	-
151-48	Corrotoman By-The-Bay	695-725	PAA	6X3	125	38	3.3	D	4.0	2	-
151-50	West Irvington No. 2	555-570 612-632	PAA	10X6	295	89	3.3	DE	3.3	24	7,000

UAA Upper Artesian Aquifer
PAA Principal Artesian Aquifer
D-Drillers Log
E-Electric Log
G-Geologic Log

WELL POTENTIAL DATA FOR LANCASTER COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Log Type	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpd/ft)
151-72	G. C. Dawson	644-664	PAA	4X2	40	35	1.1	D	1.5	3	-
151-82	Corrotomon By-The-Bay	659-679	PAA	6X3	165	99	1.7	DG	1.9	48	-

UAA Upper Artesian Aquifer
PAA Principal Artesian Aquifer
D-Drillers Log
E-Electric Log
G-Geologic Log

WELL POTENTIAL DATA FOR NORTHUMBERLAND COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Log Type	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpd/ft)
166-1	Everett Goddard	231-400	UAA	4X2	40	40	0.1	-	0.1	-	-
166-2	Haynie Product	229-269	UAA	6X3	21	100	0.2	-	0.2	-	-
166-6	River Bend Estates	646-666 672-702	PAA	6X4	60	33	1.8	DE	-	6.5	-
166-6	River Bend Estates first test	350-360 368-378 384-394 406-416 426-436	UAA	6	30	237	0.1	DE	0.1	-	-
166-9	Smith Seafood	688-708	PAA	4X2	40	55	0.7	D	1.4	6	-
166-13	Sydnor-Callao	347-356	UAA	-	39	14	2.8	D	2.8	-	-
166-16	Heathsville	413-439	UAA	8	44	70	0.6	-	0.6	-	-
166-20	Haynie Products	685-710 740-780	PAA	8X6	503	32	15.7	DE	-	-	-

UAA Upper Artesian Aquifer
PAA Principal Artesian Aquifer
D-Drillers Log
E-Electric Log
G-Geologic Log .

WELL POTENTIAL DATA FOR NORTHUMBERLAND COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Log Type	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpd/ft)
166-27	Wicomico Ridge	695-715	PAA	4X2	40	37	1.1	D	1.1	72	-
166-28	Standard Products	649-654 658-668 672-687 725-740 747-752	PAA	18X10	510	88.5	5.8	DE	5.8	24	15,000
166-44	Sherwood Forest	670-680 693-703 754-769	PAA	6X3	127	251	0.5	DG	0.6	48	-
166-46	American Central Corp Bay Quarter Shores	623-643	PAA	6X3	213	92	2.3	-	-	48	-
166-48	Lee Dale Shores	730-736	PAA	4X2	40	60	0.7	-	-	-	-
166-49	Charles Robinson	360-420	UAA	4	75	8	9.4	D	9.4	3.5	-
166-56	John B. Lowry	694-744	PAA	4X2	40	36	1.1	-	-	-	-

UAA Upper Artesian Aquifer
PAA Principal Artesian Aquifer
D-Drillers Log
E-Electric Log
G-Geologic Log

WELL POTENTIAL DATA FOR RICHMOND COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Log Type	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpd/ft)
179-4	Farnham School	331-341 351-361	UAA	6	50	23	2.2	-	2.2	2	3,500
179-6	Town of Warsaw	618-640	PAA		285	121	2.4	-	3.2	-	-
179-7	Town of Warsaw No. 2 Well	622-632 660-675	PAA	8X6	503	163	3.1	DE	3.5	24	8,500
179-9	VEPCO	317-337	UAA	4X2	35	22	1.6	D	1.6	24	-
179-16	Bell Acres Subdivision	677-697	PAA	4X2	40	36	1.1	D	1.9	48	-
179-38	W. H. Mackey	283-303	UAA	4X2	33	41	0.8	D	0.8	-	-

UAA Upper Artesian Aquifer
PAA Principal Artesian Aquifer
D-Drillers Log
E-Electric Log
G-Geologic Log

WELL POTENTIAL DATA FOR WESTMORELAND COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Log Type	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpd/ft)
196-1	Montross Lumber Co.	268-278	UAA	6X4	35	80	0.4	D	0.4	7	-
196-2	National Park Serv.	451-461	PAA	6	57	15	3.4	DEG	4.4	12	9,000
196-4	Stratford Hall	658-666	PAA	10	90	68	1.4	D	2.0	-	-
196-9	Templeman Elementary	590-620 743-773	PAA	6X4	91	136	0.7	D	0.8	12	-
196-12	Sanford Canning Co	211-221 243-253	UAA	6X4	110	69	1.6	DE	1.6	3.75	-
196-14	Stratford Harbor	568-588	PAA	6X3	100	185	0.5	-	-	-	-
196-15	Stratford Harbor #3	589-609	PAA	6X3	100	80	1.3	-	-	-	-

UAA Upper Artesian Aquifer
PAA Principal Artesian Aquifer
D-Drillers Log
E-Electric Log
G-Geologic Log

WELL POTENTIAL DATA FOR WESTMORELAND COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Log Type	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpd/ft)
196-17	Arrowhead Manufacturing	430-461 498-514 529-540 546-554 570-578 596-604 642-653 663-678	PAA	20X8	844	148	5.7	DE	6.3	28	18,000
196-23	Cabin Point No. 1	340-360 420-440 522-538 570-582 698-718	UAA and PAA	10X8	554	132	4.2	DG	4.5	24	15,000
196-24	Cabin Point No. 2	342-362 424-444 524-540 568-580 694-714	PAA	10X8	806	62	12.9	DE	13.6	24	30,000
196-25	Ira Muse	338-353	PAA	4X2	40	40	1.0	D	3.3	2	-

UAA Upper Artesian Aquifer
PAA Principal Artesian Aquifer
D-Drillers Log
E-Electric Log
G-Geologic Log

WELL POTENTIAL DATA FOR WESTMORELAND COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Log Type	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpd/ft)
196-30	National Park Service	266-271 283-288 293-298 306-321	UAA	6	50	75	0.7	DE	0.7	8	1,500
196-43	Town of Col. Beach	736-756 806-816	PAA	6	202	210	1.0	D	1.8	6	4,500
196-48	Crows Nest Harbor	226-236 302-312	UAA	6	50	260	0.2	D	0.2	24	Less than 1,000
196-56	Gordon Horner Hague	284-294 309-319	UAA	4X2	30	81	0.4	D	0.4	2	-
196-57	National Park Service	394-409 442-447	PAA	6	150	25	6.0	DEG	8.6	24	18,000
196-58	Virginia Dept of Highways	383-393	PAA	4X2	40	45	0.9	D	0.9	1	-
196-83	James Mozingo	222-232	UAA	4X2	40	50	0.8	D	0.8	1	-
196-84	C. A.Jenkins & Son	254-264	UAA	4X2	40	50	0.8	D	0.8	1	-

UAA Upper Artesian Aquifer
PAA Principal Artesian Aquifer
D-Drillers Log
E-Electric Log
G-Geologic Log

WELL POTENTIAL DATA FOR WESTMORELAND COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Log Type	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpd/ft)
196-105	Thomas Arnest	320-330	UAA	4X2	20	76	0.3	D	0.3	48	-
196-126	Ralph Merrill	370-380	PAA	4X2	40	44	0.9	D	-	-	-
196-127	Dennis Bartlett	208-218	UAA	2	5	35	0.1	D	0.1	-	-
196-129	Westmoreland State Park	384-404 423-438 463-478	PAA	6X4	55	83	0.7	DE	0.9	48	-

UAA Upper Artesian Aquifer
PAA Principal Artesian Aquifer

D - Drillers Log
E - Electric Log
G - Geologic Log

APPENDIX C

GROUNDWATER QUALITY DATA

Appendix C contains chemical quality data on the groundwater in the Northern Neck. Well numbers can be cross-referenced to Appendix A. The data listed in Appendix C includes:

State Water Control Board Number
Owner and/or Location of the Well
Date Sampled
Depth of the Well
Screen Depths in Well
The following chemical constituents in milligrams per liter (mg/l):
- Iron (Fe)
- Calcium (Ca)
- Magnesium (Mg)
- Copper (Cu)
- Lead (Pb)
- Manganese (Mn)
- Zinc (Zn)
- Sodium (Na)
- Potassium (K)
- Alkalinity
- Sulfate (SO_4)
- Fluoride (F)
- Chloride (Cl)
- Nitrite (NO_2)
- Nitrate (NO_3)
- Total Hardness
- Total Solids
- Dissolved Solids
- Specific Conductivity
- pH
- TOC
- Silica (SiO_2)

The data in Appendix C is a composite listing of water samples taken by the State Water Control Board and by other governmental agencies.

LANCASTER COUNTY

GROUNDWATER QUALITY DATA

SWCB NUMBER	OWNER AND/ OR PLACE	DATE	AQUIFER	TOTAL DEPTH	SCREEN DEPTH	pH (LAB)	ALKALINITY	TOTAL SOLIDS	DISSOLVED SOLIDS	CHLORIDE	HARDNESS	SO_4	NO_2	NO_3	FLUORIDE	TOC	Ca	SiO_2	Cu	Fe	METALS Pb	Mg	Mn	Zn	Na	K	SPECIFIC CONDUCTANCE
151-1	Town of Kilmarnock #2	01/12/77	PAA	740	676	8.5	386	483	483	3.0	7.0		0.05-	0.02	3.15	4	1.0			0.1		0.3	0.01		390	5.0	
		10-21-76				8.3	690	497	492	3.0	10.0		.21		3.0	1-	1.0			0.1-		0.2	0.01-		230	5.1	
		07-02-76				8.7	396	494	494	5.0	2.0	23.8		0.18	2.6	2	1.0			0.1-		0.2	0.01-		260	5.2	
		05-04-76				8.1	412	488	488	3.0	8.0-	25.2		0.05-	3.0	2	2.0			0.1-		0.3	0.01-		340	4.7	
		02-25-76				8.1	397	512	504	5.0	6.0	23.3		0.05-	2.9	6	2.0			0.8		0.3	0.01		196	4.2	
		10-28-75				8.1	386	498	496	5.0	10.0	24.0			3.1	6	2.0			0.1		0.3	0.01-		185	4.3	
		08-23-75				8.1	382	504	504	4.0	48.0	35.7	0.05	0.05-	3.0					0.1-		0.3	0.01		360	4.6	
		06-26-75				8.0	392	533	521	1.0	8.0	21.5			3.1	4	1.0			0.1-		0.4	0.01-		240	4.7	
		02-19-75				8.0	393	521	521	4.0	6.0	21.2			3.0	8	1.0			0.1-		0.4	0.01-		130	4.1	
		11-08-71				8.0				0.5	2.0	20.4		0.04-	3.3		0.2	10.4	0.02	0.02			0.03			5.0	
151-3	R. T. Herndon	08-11-76	PAA	634	601	7.9	234	503	503	7.0	22.0		0.05-		2.84	11	2.0			0.1		0.3	0.01-		280	4.1	
151-8	W. F. Morgan & Sons Seafood	08-10-76	UAA	337	312	8.2	547	696	696	3.0	8.0		0.05-		3.5	4	5.0			0.1		2.1	0.01-		330	10.3	
151-22	Laural Point #2	03-07-73	PAA	664	649	8.5	422			0.5-	3.79	25.0	0.003	0.35	2.85		0.94	15.2	0.03	0.3	0.01-	0.35	0.01-		213	6.13	
151-24	W. R. Pittman & Sons	08-11-76	PAA	555	535	8.1	250	306	306	2.0	29.0			0.05	1.01	7	6.0			0.1		2.5	0.01		110	8.0	

LANCASTER COUNTY

GROUNDWATER QUALITY DATA

SWCB NUMBER	OWNER AND/ OR PLACE	DATE	AQUIFER	TOTAL DEPTH	SCREEN DEPTH	pH (LAB)	ALKALINITY	TOTAL SOLIDS	DISSOLVED SOLIDS	CHLORIDE	HARDNESS	SO_4	NO_2	NO_3	FLUORIDE	TOC	Ca	SiO_2	Cu	Fe	METALS Pb	Mg	Mn	Zn	Na	K	SPECIFIC CONDUCTANCE
151-27	Kilmarnock #1	01-03-71	PAA	728		8.9	401			0.5	4.0	30.0		1.11				14.0		0.05			0.05		200	5.5	
151-32	Tides Inn Sub-division	07-12-74	PAA	674	556	8.5	391			0.5	6.0	27.7	0.03	0.04	3.2		0.68	12.4	0.01-	0.09	0.01-	0.3			130	6.1	720
151-35	Town of Foxwells	08-10-76	PAA	668	648	8.3	339	709	709	101	5.0			0.31	3.15	2	2.0			0.1		0.4	0.01-		430	5.1	
		07-15-74					344				3.98	100.0	0.39	0.13	2.9		0.95		0.01-		0.01	0.34			180		980
151-36	Irvington-East	05-22-72				8.6	381			0.5	3.0	53.6			3.4				0.03	0.25		0.02	0.01		218	6.0	
151-40	Town of Lively	08-11-76				7.9		319	319	1.0	46.0			0.05-	1.23	9	12.0			0.1-		4.8	0.01-		103	9.1	
		05-02-74				8.3	207			0.5	45.0	1.5	0.2	0.04	0.86	7	10.0	42.0	0.01-	0.03	0.01-	4.2	0.01-		66.5	14.0	394
		03-27-74				8.7	250			0.5	41.0	5.3	0.07	0.09	1.2		8.8	39.6	0.01	0.04	0.01	3.8	0.01		85.0	23.0	483
		11-09-71				8.5	234			2.0	46.0	3.8		0.09	0.98		12.0	44.0	0.008	0.14	.0008	3.8	0.03		85.0	11.5	
151-41	North Weems	08-10-75	PAA	651	558												2.0			0.1		0.6	0.01-		350	5.3	
		04-04-75				8.9	417			0.5	5.0	21.4	0.03	0.09	3.35		1.1	17.6	0.02	0.1	0.01-	0.54	0.01-		192	6.5	746
151-42	Weems	04-04-75	PAA	636	616	8.4	386			0.5-	2.0	25.8	0.03	0.4	3.1		0.7	13.2	0.01	0.08	0.01-	0.3	0.01-		125	6.2	700
151-44	Lancaster Court House	08-10-76	PAA	805	647	8.4	394	489	461	0.0	6.0			0.05-	2.17	3	4.0			0.1		1.3	0.01-		280	6.7	
151-45	Churchfield Subdivision	08-10-76	PAA	739	691	8.3	369	516	516	2.0	2.0			0.18	3.25	1	2.0			0.1		0.2	0.01-		290	5.0	
		11-29-73				8.3					3.0	30.4		2.95	2.95			13.2		0.13	0.01	0.27	0.02		185	7.0	568

LANCASTER COUNTY

GROUNDWATER QUALITY DATA

SWCB NUMBER	OWNER AND/ OR PLACE	DATE	AQUIFER	TOTAL DEPTH	SCREEN DEPTH		pH (LAB)	ALKALINITY	TOTAL SOLIDS	DISSOLVED SOLIDS	CHLORIDE	HARDNESS	SO_4	NO_2	NO_3	FLUORIDE	TOC	Ca	SiO_2	Cu	Fe	METALS						SPECIFIC CONDUCTANCE
																						Pb	Mg	Mn	Zn	Na	K	
151-46	Heritage Point#2	07-24-73	PAA	646	625			398			0.5-	9.0	16.3	0.3		2.3		.88	46.6	0.35	0.1-	0.02	0.38	0.01-		168	6.5	673
151-47	Brightwater	07-12-74	PAA	690	670		8.4	353			74.0	16.0	133.0	0.03-	0.04	2.45		4.0	19.2	0.01-	0.28	0.01	1.54	0.01	.14	256	16.0	1800
		11-28-73					7.7	349			10.0	17.0		1.35	0.09	2.49		4.3	15.6	0.02	0.31	0.01	1.66	0.05	.27	400	14.7	1515
151-48	Corrotoman-By-The-Bay	01-06-69	PAA	737	695		8.45	371				5.0			0.04-	2.55					0.01			0.01				
151-50	Haywoods Dock	08-11-76	PAA	325	555	570	8.5	443	550	550	7.0	22.0			0.05-	2.07	1-	9.0			1.5		9.0	0.04		9	1.4	
151-51	West Irvington	03-01-74	PAA	675	555			308	498		6.0	6.37	22.6			2.97		1.15	5.3		0.11		0.85			194		
151-54	Brown's Store	08-11-76	PAA	800	770		8.3	381	493	493	2.0	2.0-			0.14	1.86	2	2.0			0.1-		0.3	0.01-		340	3.5	
151-61	Little Bay Community	07-27-73	PAA	639	619		8.7	436			0.5	6.0	51.2	0.03	0.04	3.0		1.43	12.8	0.07	0.2	0.01	0.51	0.01		215	7.0	1011
151-63	Cove Colony	11-19-71	PAA	750			8.7	270			0.5		22.0							0.05							5.4	
151-64	Lancaster Courthouse	07-12-74	PAA	541			8.6	404			0.5	13.0	4.7	0.3	0.89	1.83		3.8	21.2	0.02	0.06	0.01-	1.29	0.01-	0.01	120	12.0	700
151-65	Lancaster Shore	07-12-74	UAA	805			8.5	203			1.0	27.12		0.3-	0.04	0.67		7.4	18.4	0.03	0.14	0.01-	2.1	0.01-	0.02		13.0	310
151-66	Laurel Point	03-07-73	PAA	755			8.3	365			0.5	2.51	26.4	.002	0.04	1.8		0.63	17.4	0.01	0.5	0.01-	0.23	0.03	.07	185	4.35	

LANCASTER COUNTY

GROUNDWATER QUALITY DATA

SWCB NUMBER	OWNER AND/ OR PLACE	DATE	AQUIFER	TOTAL DEPTH	SCREEN DEPTH	pH (LAB)	ALKALINITY	TOTAL SOLIDS	DISSOLVED SOLIDS	CHLORIDE	HARDNESS	SO_4	NO_2	NO_3	FLUORIDE	TOC	Ca	SiO_2	Cu	Fe	METALS Pb	Mg	Mn	Zn	Na	K	SPECIFIC CONDUCTANCE
151-67	Whitestone Shellfish Lab.	07-11-74	PAA	661		8.3	401			0.5-	6.0		0.03-	2.21	3.3		1.1	43.2	0.01	0.04	0.01-	0.36	0.01-	0.01-	150	6.92	800
		11-08-71				8.9	414			1.0	6.0	35.2		0.04	3.15			14.8	0.02	0.05		0.5-	0.02		215		
151-70	Kilmarnock High-Way Shop	08-10-76	PAA	115		6.1	21	120	118	29.0	31.0			1.6	0.07	1-	11.0			0.1		3.8	0.01-		29	1.5	
151-72	G. C. Dawson	08-10-76	PAA	670	644	8.5	367	468	464	3.0	10.0			0.05-	2.09	4	6.0			0.1-		1.7	0.01-		240	8.8	
151-73	Rev. James R. Carter	08-11-76	WT	60	60	6.0	17	159	131	11.0	33.0			3.9	0.01-	2	6.0			0.1		2.4	0.01-		270	9	

NORTHUMBERLAND COUNTY

GROUNDWATER QUALITY DATA

SWCB NUMBER	OWNER AND/ OR PLACE	DATE	AQUIFER	TOTAL DEPTH	SCREEN DEPTH		pH (LAB)	ALKALINITY	TOTAL SOLIDS	DISSOLVED SOLIDS	CHLORIDE	HARDNESS	SO_4	NO_2	NO_3	FLUORIDE	TOC	Ca	SiO_2	Cu	Fe	METALS						SPECIFIC CONDUCTANCE
																						Pb	Mg	Mn	Zn	Na	K	
166-6	River's Band Estate	08-11-76	PAA	730	646	702	8.4	353	473	473	2.0	2.0-			0.20	1.7	1	2.0			0.2		0.3	0.01-		260	3.6	
166-9	Smith Seafood	08-23-76	PAA	718	688	708	8.5	338		450	11.0	14.0		0.05-		2.29	1	1.0			0.01-		0.2	0.01-		200	4.6	
166-10	Bay Quarter Shores Clubhouse	01-31-75	PAA	620	596	616	8.6	288			2.5	6.0		0.03-	0.49	0.98		0.55	13.6	0.01	.09		0.44	0.01-	0.09	140	6.15	530
166-13	Town of Calleo	08-18-76	UAA	356	347		7.7	156	222	218	2.0	57.0		0.01	0.13	0.67	3	16.0		0.01-	.1		6.1	0.01-		51	12.0	
166-14	Ditchley	12-16-76	PAA	640	620	640	8.4	327			6.0	20.0			0.26	1.4	4	4.0			0.1-		0.21	0.01-		280	10.1	
		08-23-76					8.4	364	459	555				0.05-		1.34		6.0			0.1		2.3	0.01-		139	10.4	
166-15	Glebe Point	06-02-68	PAA				8.5			448	5.0	4.0	21.6		0.013	1.36			12.1	0.025-	0.1		0.04	0.05-	0.88			
166-16	Town of Heathsville	08-11-76	PAA	448	412	438	8.1	272	364	364	2.0	14.0			0.19	1.29	2	7.0			0.1		3.2	0.01-		91	7.5	
		10-07-74					8.5	262			1.5	30.0	0.5-	0.03-	2.17	1.3		5.73	17.6	0.04	0.08	0.01-	2.8	0.01-	0.37	110	12.0	450
166-26	Haynie Products Inc.	01-12-77	PAA	809	685	780	8.5	330	451	451	9.0	4.0		0.01-	0.2	2.2	5	2.0			0.1		0.3	0.01		310	5.0	
		10-21-76					8.2	565	448	452	8.0	2.0			0.05-	2.02	2	1.0			0.1-		0.2	0.01		230	4.3	
		07-13-76					8.1	77	560	552		40.0	30.0		0.05-	2.1	4	1.0			0.1-		0.1	0.01-		183	4.3	
166-27	Wicomico Ridge Subdivision	06-26-75	PAA	723	695	715	8.1	365	490	477	3.0	2.0	22.3			2.2	6	1.0			0.1-		0.4	0.01-		320	5.6	
		03-20-75					8.0	370	479	471	3.0	6.0	22.1			2.2	5	2.0			0.1-		0.4	0.01		155	4.8	
166-41	Bell's Cove	09-28-73	PAA	400			7.9	158			1.0	53.0	5.1	0.03	2.22	0.52		12.5	32.8	0.01	0.28		5.0	0.01-	0.06	46.6	13.0	257

NORTHUMBERLAND COUNTY

GROUNDWATER QUALITY DATA

SWCB NUMBER	OWNER AND/ OR PLACE	DATE	AQUIFER	TOTAL DEPTH	SCREEN DEPTH		pH (LAB)	ALKALINITY	TOTAL SOLIDS	DISSOLVED SOLIDS	CHLORIDE	HARDNESS	SO_4	NO_2	NO_3	FLUORIDE	TOC	Ca	SiO_2	Cu	Fe	METALS						SPECIFIC CONDUCTANCE
																						Pb	Mg	Mn	Zn	Na	K	
166-42	Fleeton	09-27-74					8.7	331			1.5	2.0	30.4	0.03-	0.09	2.3		0.48	14.0	0.05	0.18		0.23	0.01	0.47	178	5.3	660
166-43	Indian Creek Yacht Club	09-25-73	PAA	635			8.8				32.5	2.6	11.0			2.66		1.07	2.0		0.03					122		
166-45	Capt. A. H. Cowart	12-16-76	UAA	315	298	308	8.0	366	258	258	1.0	72.0			0.05-	0.48	4	14.0			0.2		0.72	0.01		108	13.0	
166-48	Lee Dale Shores	12-16-76	PAA	736	730	736	8.6	387	472	472	3.0	6.0			0.08	1.7	4	1.0			0.1		0.03	0.01		340	3.7	
166-49	Charles Robinson	08-23-76	PAA	420	360	420	8.1	548	982	982	169.0	52.0			0.05-	1.84	2	14.0			0.5		5.6	0.01-		380	1.6	
166-51	Horace Washington	08-23-76	WT	70	65	70	6.4	21	97	97	10.0	32.0		1.3		0.06	1-	11.0			0.01-		2.1	0.01-		15	1.5	
166-55	Crowther	08-23-76	PAA	710	690	700	8.4	299	402	402	3.0	32.0		0.05-		1.3	1	6.0			0.01-		1.1	0.01-		149	5.1	
166-56	Cap'n John's	12-16-76	PAA	744	694	734	8.4	359	489	485	4.0	22.0			0.05-	2.8	4	1.0			0.1-		0.04	0.01		430	4.8	
		08-23-76					8.5	356	461	457				0.05-		5.97	1	4.0			0.01-		0.9	0.01-		310	6.0	
166-57	Fallin	08-23-76	WT	52	52		6.1	18	66	62				0.8		0.05	1	7.0			0.01-		0.9	0.01-		4	0.8	
166-61	Russel Garner	12-16-76	UAA	415	368	378	8.1	29	220	220	1.0	44.0			0.05-	0.56	4	14.0			0.1		0.56	0.01		103	11.8	
	Wicomico Ridge Area	04-29-76	WT	30	25		6.0	28	107	107	17.0	45.0	3.1		4.9	0.1-	2	14.0			0.1-		4.8	0.01		19	2.1	

RICHMOND COUNTY

GROUNDWATER QUALITY DATA

SWCB NUMBER	OWNER AND/ OR PLACE	DATE	AQUIFER	TOTAL DEPTH	SCREEN DEPTH		pH (LAB)	ALKALINITY	TOTAL SOLIDS	DISSOLVED SOLIDS	CHLORIDE	HARDNESS	SO_4	NO_2	NO_3	FLUORIDE	TOC	Ca	SiO_2	Cu	Fe	METALS						SPECIFIC CONDUCTANCE
																						Pb	Mg	Mn	Zn	Na	K	
179-4	Farnham School	08-18-76	PAA	373	331	361			236	236	2.0	82.0		0.01-	0.05-	0.57	3	22.0		0.01-	0.2		6.5	0.01-		34	12.5	
179-7	Town of Warsaw	02-22-77	PAA	702	622	675	8.3	271	361	358	1.0	20.0		0.01-	0.05-	2.2	6	2.0			0.1-		0.4	0.01-		220	4.7	
		11-26-76					7.9	264	352	344	1.0	6.0		0.01	0.05-	2.76	3	2.0			0.2		0.3	0.01		138	4.4	
		08-17-76					7.9	277			1.0-	6.0			0.05-	1.91	3	2.0			0.1-		0.3	0.01-		115	4.7	
		05-04-76					7.6	281	340	340	2.0-	8.0-	7.2		0.05-	2.1	2	2.0			0.2		0.4	0.01-		171	4.4	
		11-10-75					8.0	280	354	332	2.0	10.0	8.5	0.01-	0.05-	2.3	8	4.0			0.1		1.5	0.01-		121	3.8	
179-15	Levi Strauss	08-17-76	PAA	750	637	702	8.1	244			1.0-	4.0		0.05-		2.4	2	1.0			0.1-		0.1	0.01-		141	3.6	
176-16	Bell Acres Subdivision	08-18-76	PAA	700	677	697	8.3	256	339	337	2.0	12.0		0.01-	0.05-	2.42	5	1.0		0.01	0.01-		0.1	0.01-		147	2.5	
179-21	Douglas Drilling	08-17-76	PAA	458	438	453	7.9	226			1.0-	6.0			0.08	2.02	3	1.0			0.1		0.1	0.01-		127	3.6	
179-22	R. H. Mallory	08-17-76	PAA	456	429		8.0	235			2.0	8.0			0.08	2.73	2	2.0			0.1		0.2	0.01-		200	4.1	
179-25	Durwood O'Bier	08-17-76		400			7.6	144			4.0	114.0			0.05-	0.46	2	34.0			0.1-		9.3	0.01-		23	10.9	
179-29	Lawrence Jenkins	08-18-76	UAA	220	160	220	7.9	209	285	285	2.0	35.0		0.01-	0.05-	1.02	4	10.0			0.01-	0.01-	3.8	0.01-		80	9.9	
179-40	Norman A. Dart	08-18-76	PAA	854	834	844	8.0	171	246	240	4.0	59.0		0.01-	0.05-	0.65	5	15.0		0.01-	0.1		6.4	0.01-		53	13.9	
179-42	James Shelton	04-05-77	UAA	233	221		8.1	239	313	313	20.0	30.0		0.01-	0.05-	0.94	6											
179-43	Robert W. Lowry Jr.	12-16-76	UAA	230	218	228	8.3	157	267	267	1.0-	22.0			0.05-	0.89	4	8.0			0.1		0.32	0.01		142	9.2	

WESTMORELAND COUNTY

GROUNDWATER QUALITY DATA

SWCB NUMBER	OWNER AND/ OR PLACE	DATE	AQUIFER	TOTAL DEPTH	SCREEN DEPTH		pH (LAB)	ALKALINITY	TOTAL SOLIDS	DISSOLVED SOLIDS	CHLORIDE	HARDNESS	SO_4	NO_2	NO_3	FLUORIDE	TOC	Ca	SiO_2	Cu	Fe	METALS						SPECIFIC CONDUCTANCE
																						Pb	Mg	Mn	Zn	Na	K	
196-8	Oak Grove School	04-05-77	UAA	267	236		8.1	248	348	348	2.0	44.0		0.01-	0.18	1.5	6											
		09-28-76					7.7	252	335	335	1.0	30.0			0.15	0.29	3											
196-11	Coples High School	04-05-77	UAA	345	312	322	8.0	165	238	238	1.0	70.0		0.01-	0.05-	0.66	6											
196-13	Stratford Harbour Clubhouse	09-28-76	PAA	595	574	589	7.7	318		422	2.0	10.0			0.12	2.47	1											
196-15	Stratford Harbor	09-28-76	PAA	653	589	609	7.9	319	415	415	2.0	6.0			0.05-	4.74	1											
196-17	Arrowhead	09-29-76	PAA	817	430	604	7.8	315	396	396	1.0-	14.0			0.12	2.55	1-											
196-18	Colonial Beach	09-29-76	PAA	654	600		7.6	162	265	265	2.0	6.0			0.05-	1.41	1-											
		09-29-76					7.2	160	270	270	2.0	6.0			0.05-	1.54	1-											
196-38	Kinsale	09-29-76		280			8.0	165	258	258	1.0	58.0			0.22	0.63	1-											
196-40	Montross Court-house	09-29-76	PAA	560	541		8.0	265	357	357	1.0	14.0			0.05-	2.39	1-											
196-47	Sandy Point	09-29-76					7.9	308	380	380	1.0	14.0			0.05	0.87	2											
196-48	Stratford Harbour #3	09-28-76	UAA	330	226	312	7.7	304	400	400	3.0	12.0			0.13	2.12	1											
196-49	Westmoreland St. Park	09-29-76	PAA	600			7.6	206	298	298	3.0	10.0			0.05-	1.84	2											

WESTMORELAND COUNTY

GROUNDWATER QUALITY DATA

SWCB NUMBER	OWNER AND/ OR PLACE	DATE	AQUIFER	TOTAL DEPTH	SCREEN DEPTH		pH (LAB)	ALKALINITY	TOTAL SOLIDS	DISSOLVED SOLIDS	CHLORIDE	HARDNESS	SO_4	NO_2	NO_3	FLUORIDE	TOC	Ca	SiO_2	Cu	Fe	METALS Pb	Mg	Mn	Zn	Na	K	SPECIFIC CONDUCTANCE
196-53	Town of Montross	11-26-76	PAA	702	549	631	7.7	280	342	338	1.0-	6.0		0.01-	0.05-	3.74	4	2.0			0.1-		0.4	0.01-		171	5.2	
		05-01-76					7.9	289	357	353	2.0	8.0-	8.3		0.08	2.4	4	2.0			0.2		0.5	0.01		177	4.3	
		11-10-75					7.8	315	368	333	2.0	8.0	8.5	0.01-	0.05-	2.5	10	2.0			0.1-		0.6	0.01	0.56	133	3.5	
196-57	George Washington Park	04-05-77	PAA	667	451	466	8.1	217	310	310	1.0	36.0		0.01-	0.05-	2.0	7											
		09-29-76					7.8	229			4.0	20.0			0.05-	2.23	2											
196-58	Potomac Mills Highway Shop	12-16-76	PAA	401	383	393	8.4	43	402	396	2.0	2.0			0.05-	1.6	3	1.0			1.0		0.07	0.03		160	5.9	
		09-28-76					7.4	209	317		1.0	40.0			0.07	0.79	2											
196-81	Randolph Smith	09-28-76	UAA	260	260		8.0	176	259	0	1.0	42.0			0.05-	0.70	2											
		08-18-76	UAA				8.1	175	263	259	1.0	39.0		0.01-	0.05-	0.70	5	14.0		0.01	0.5		4.4	0.01-		62.0	11.8	
196-83	Jim's Seafood	09-27-76	UAA	233	222	232	7.9	160	264	264	3.0	44.0			0.05-	0.69	1											
196-84	Jenkins & Son	08-18-76	UAA	265	254	264	8.1	173	242	234	2.0	39.0		0.01-	0.05-	0.67	4	10.0		0.03	0.1-		3.6	0.01-		23	11.1	
196-91	Hague Highway Shop	12-16-76	WT	32	32													12		0.2			0.39	0.05		48	1.3	
196-102	Coles Pt. Marine	09-27-76	UAA	240	240		8.4	234	329	329	1.0	36.0			0.05-	0.88	2											
196-108	Westmoreland Sunoco	08-18-76	WT	28	28		6.1	26	126	126	8.0	51.0		0.01-	8.5	0.03	9	14.0		0.81	0.01-		6.5	0.01-		8	3.5	
196-113	Chas. Baylor	04-05-72	PAA	652	617	637	7.7	124	211	211	1.0	36.0		0.01-	0.05-	0.78	6											

WESTMORELAND COUNTY

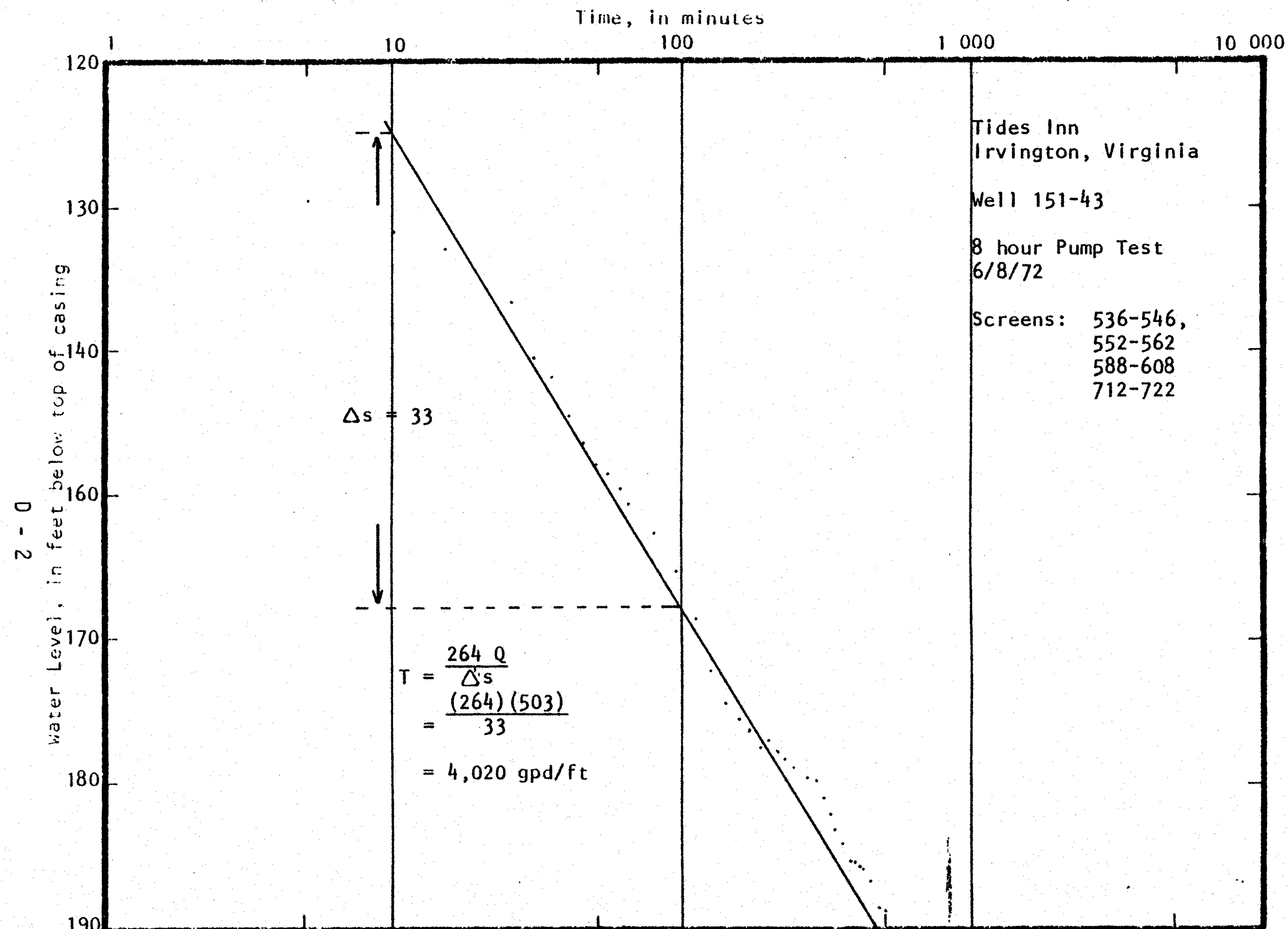
GROUNDWATER QUALITY DATA

SWCB NUMBER	OWNER AND/ OR PLACE	DATE	AQUIFER	TOTAL DEPTH	SCREEN DEPTH		pH (LAB)	ALKALINITY	TOTAL SOLIDS	DISSOLVED SOLIDS	CHLORIDE	HARDNESS	SO_4	NO_2	NO_3	FLUORIDE	TOC	Ca	SiO_2	Cu	Fe	METALS Pb	Mg	Mn	Zn	Na	K	SPECIFIC CONDUCTANCE
196-114	Lewis W. English	04-05-77	UAA	343	332	342	7.8	143	214	214	1.0-	72.0		0.01-	0.1	0.5	3											
		12-16-76					8.1	191	235	235	1.0	70.0			0.14	0.51	7	17.0			0.1-		0.62	0.01		89	11.1	
196-115	Arnold Usual	09-05-77	UAA	208	196	206	8.0	255	332	332	2.0	44.0		0.01-	0.05-	1.15	6											
196-116	Carmel Methodist Church	12-16-76	UAA	347	327	342				278								18.0			0.4		0.46	0.02		20	2.1	
196-117	Warren Perry	12-16-76	PAA	392	377	387	8.0	307	278		1.0	2.0			0.05-	1.4	3	1.0-			0.1		0.03	0.01		140	3.6	
196-127	Dennis Bartlett	04-05-77	UAA	228	208	218	8.1	133	229	229	1.0-	28.0		0.01-	0.05-	0.54	4											
196-130	Stratford Harbour Woodberry Drive	09-28-76	PAA	627			7.9	274	392	392	2.0	6.0			0.09	2.15	2											

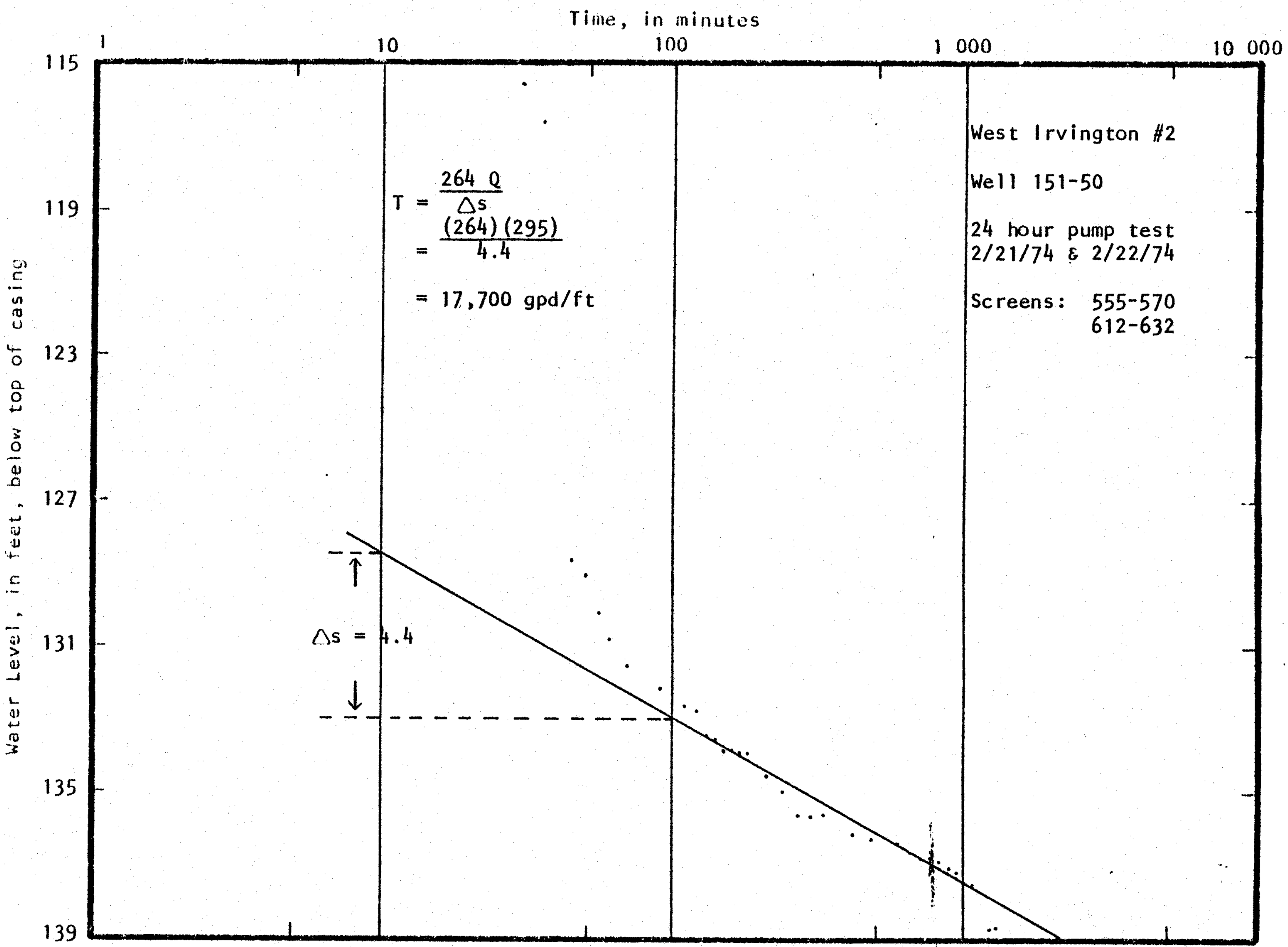
APPENDIX D

GRAPHS OF TRANSMISSIBILITY

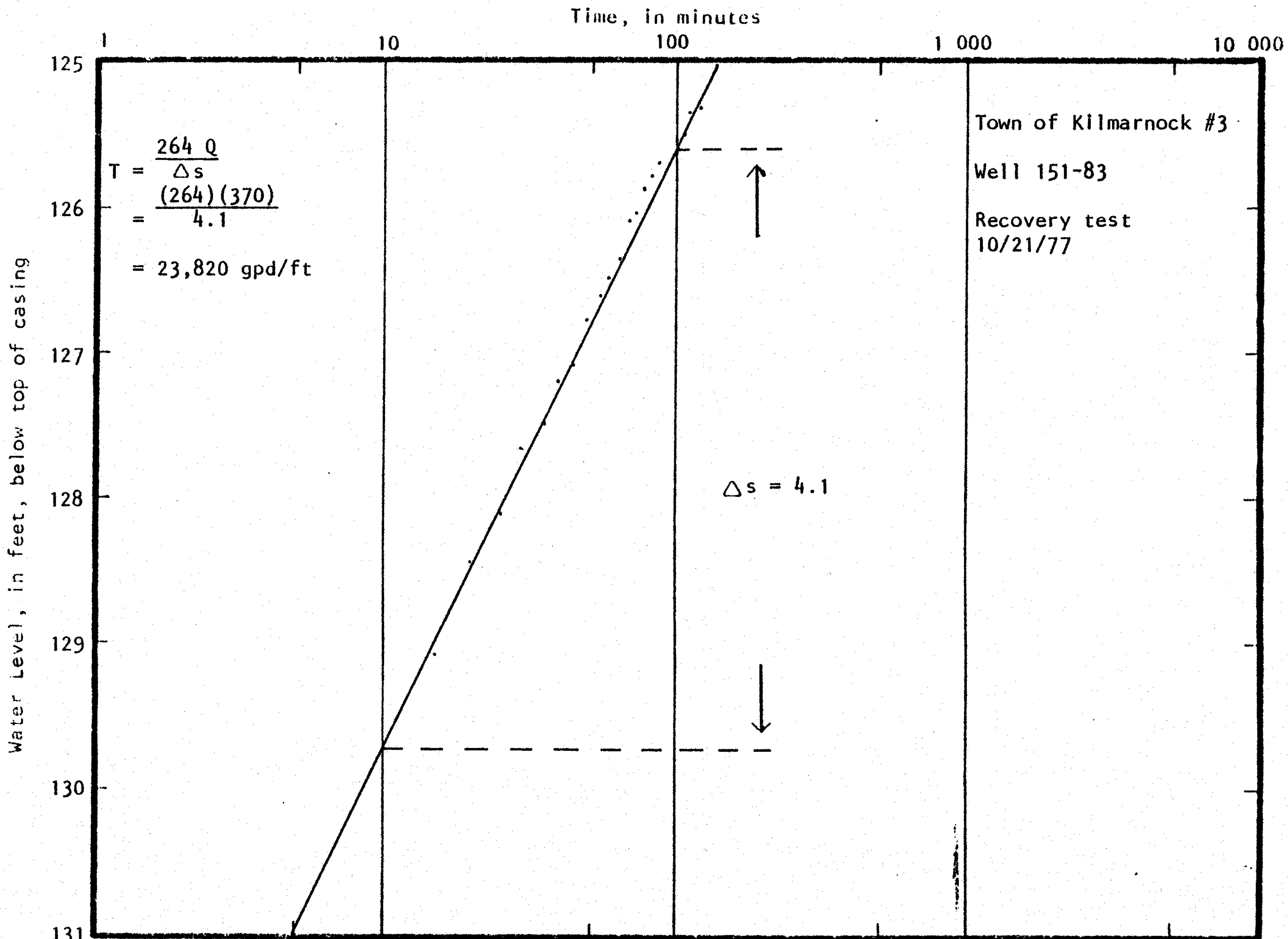
Appendix D contains semilog plots of time versus water levels of twelve wells located in the Northern Neck. Well numbers can be cross-referenced to Appendix A.



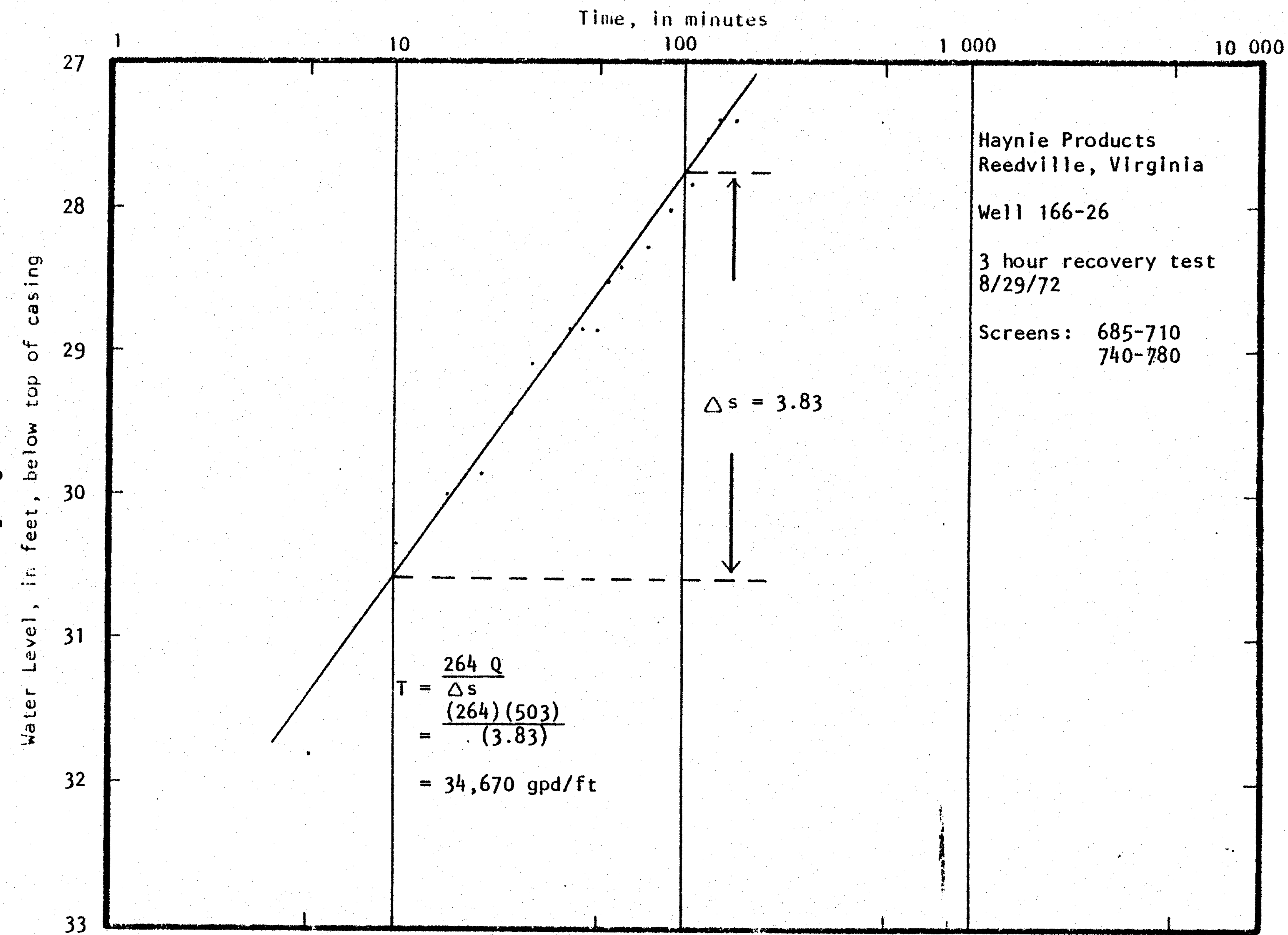
Source: State Water Control Board



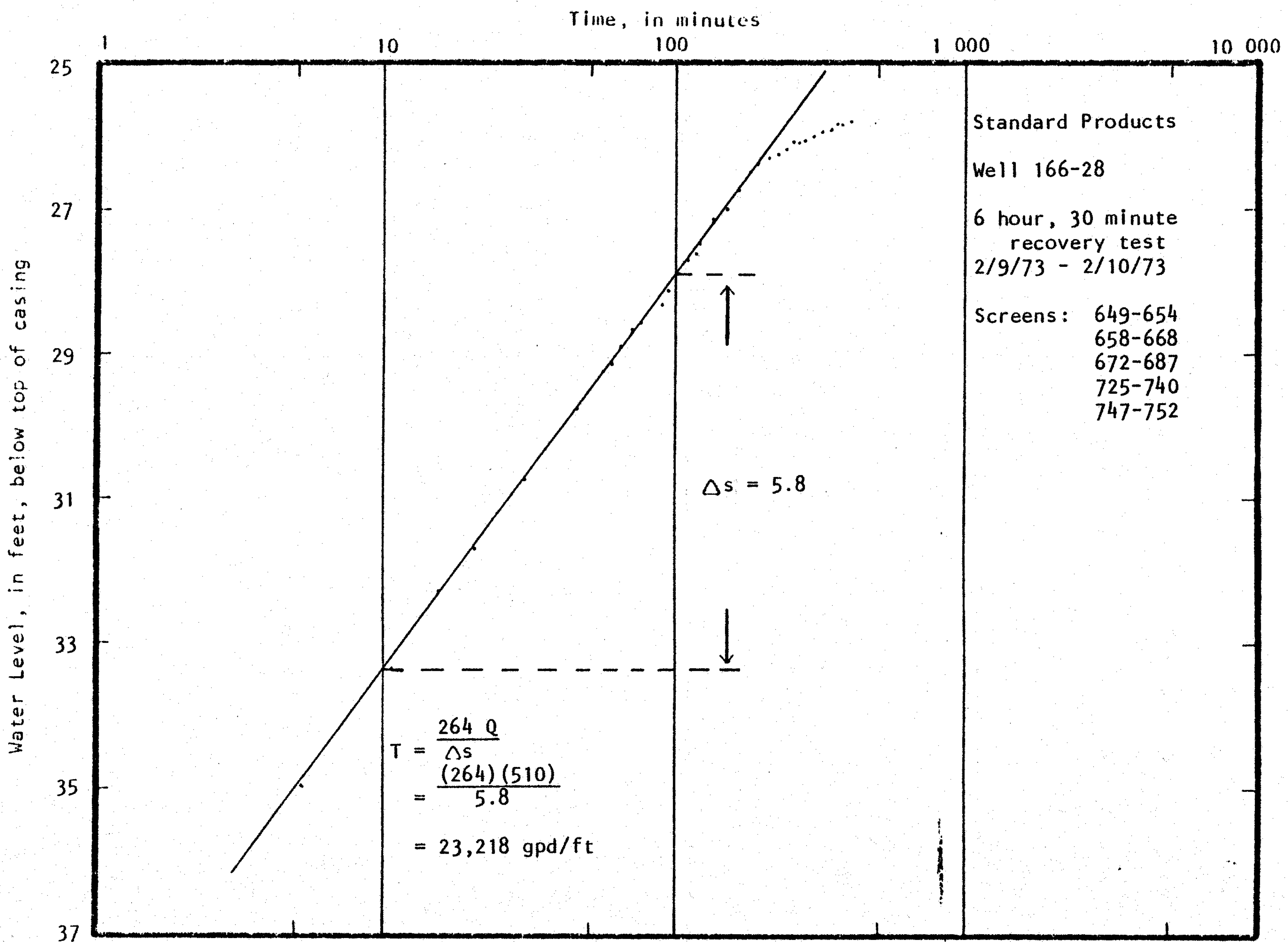
Source: State Water Control Board



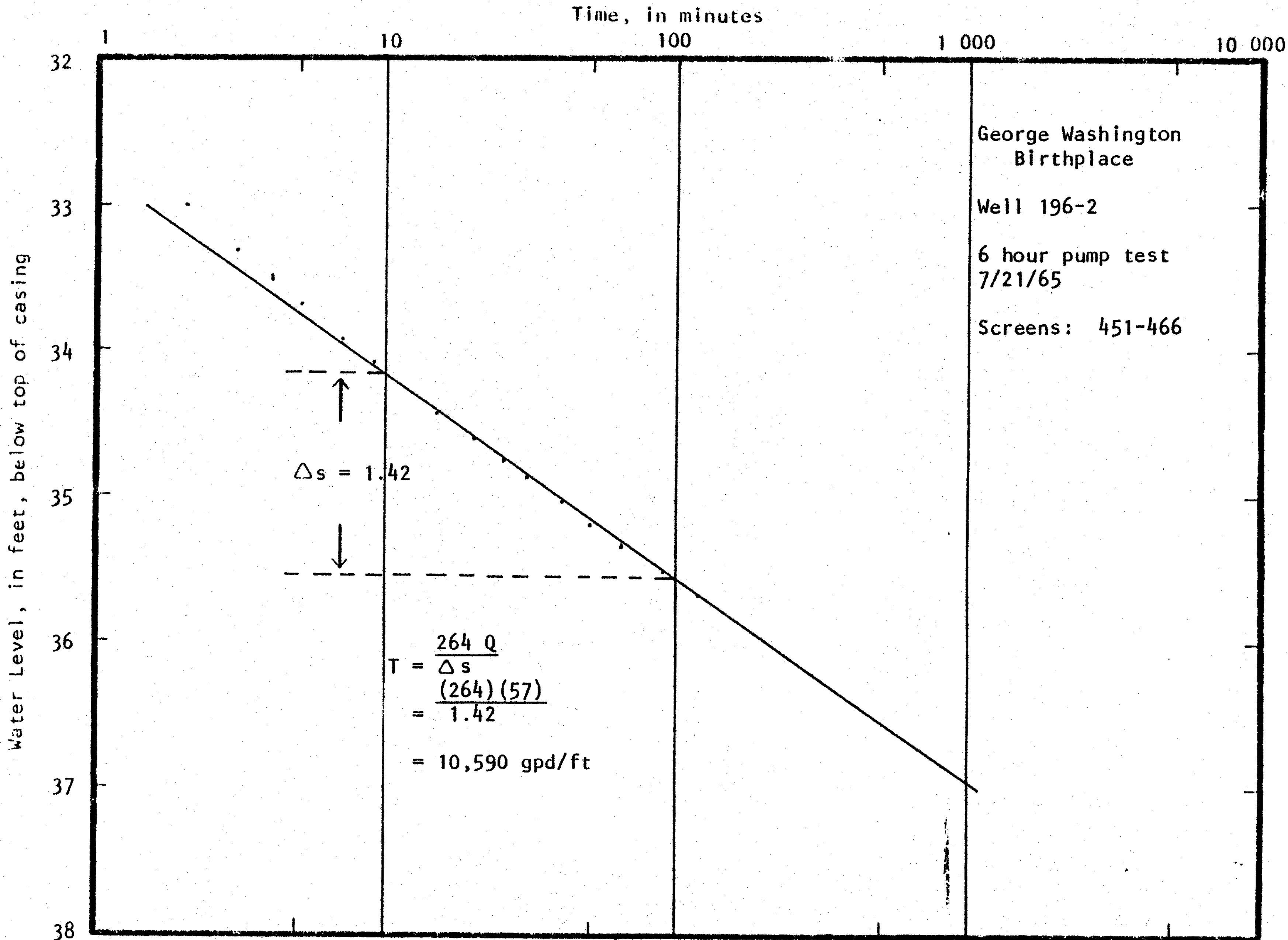
Source: State Water Control Board



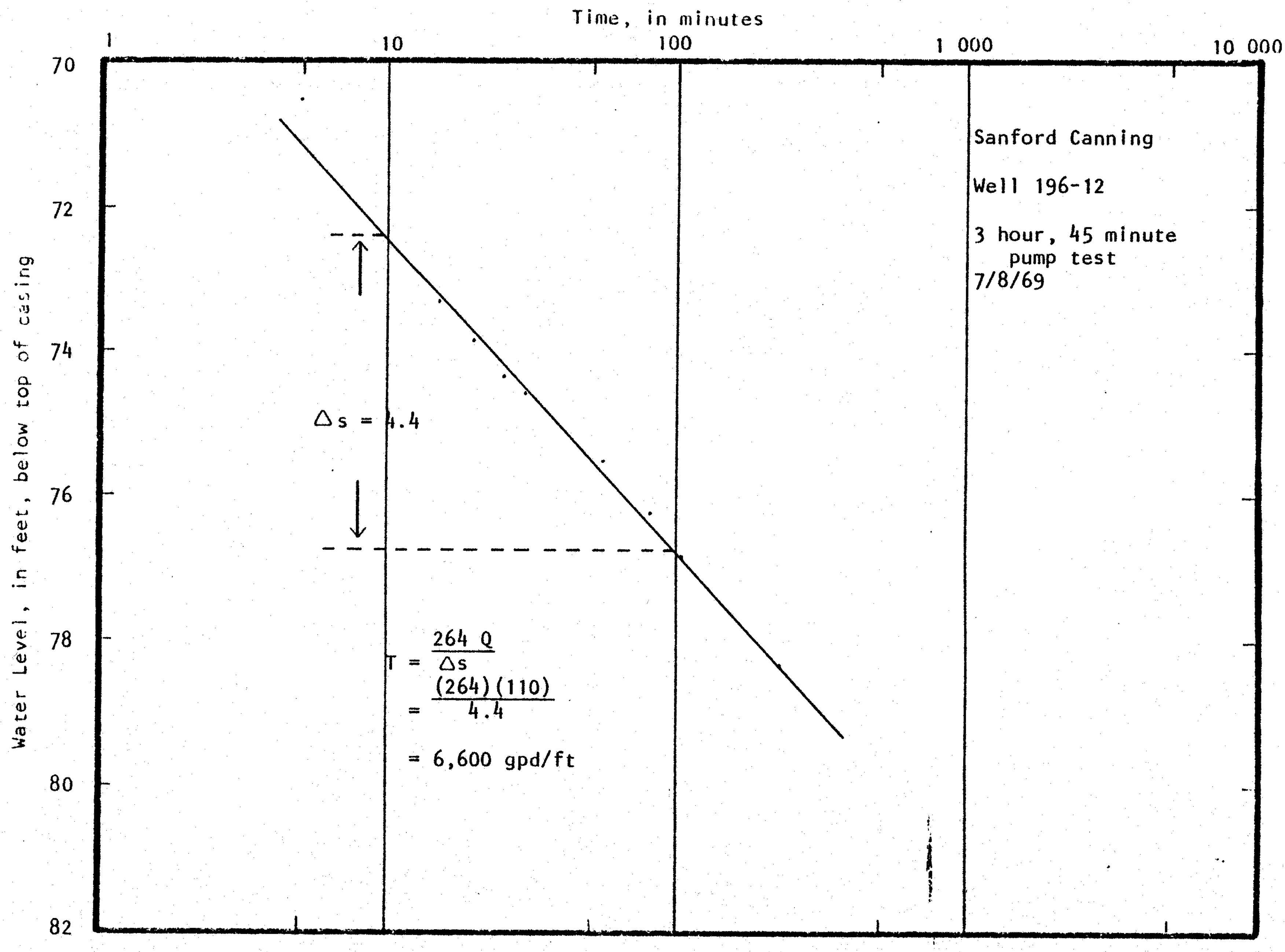
Source: State Water Control Board



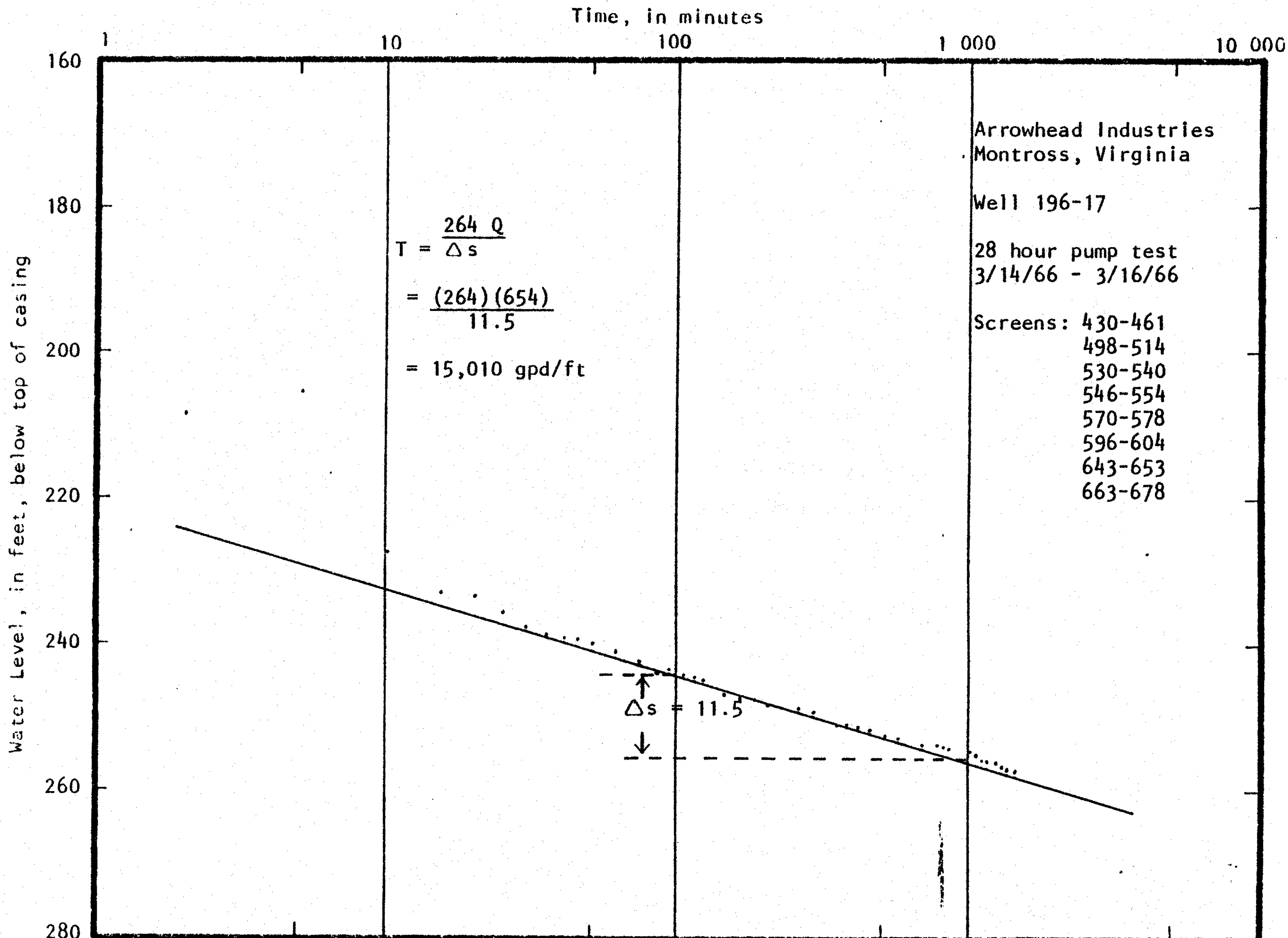
Source: State Water Control Board



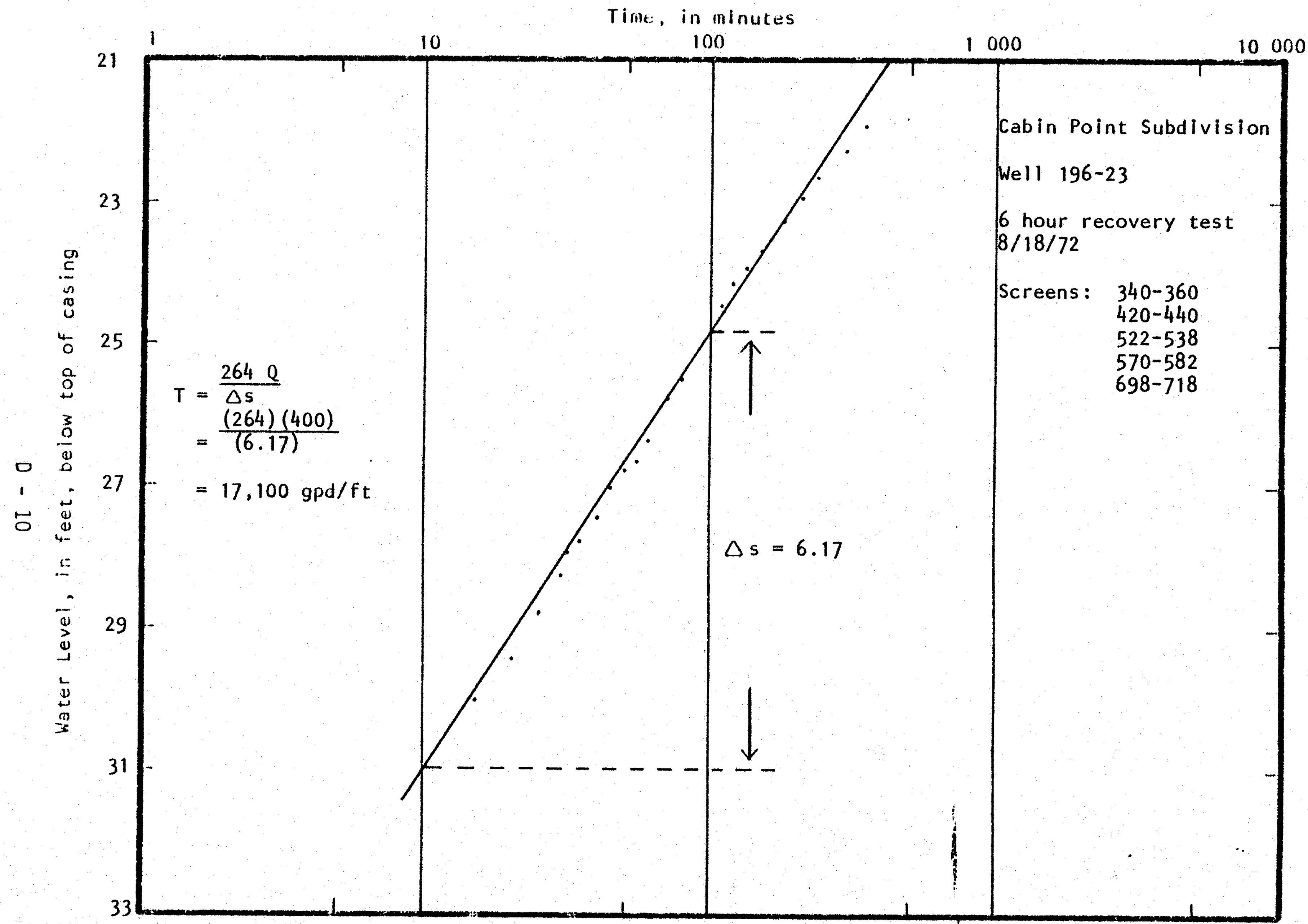
Source: State Water Control Board



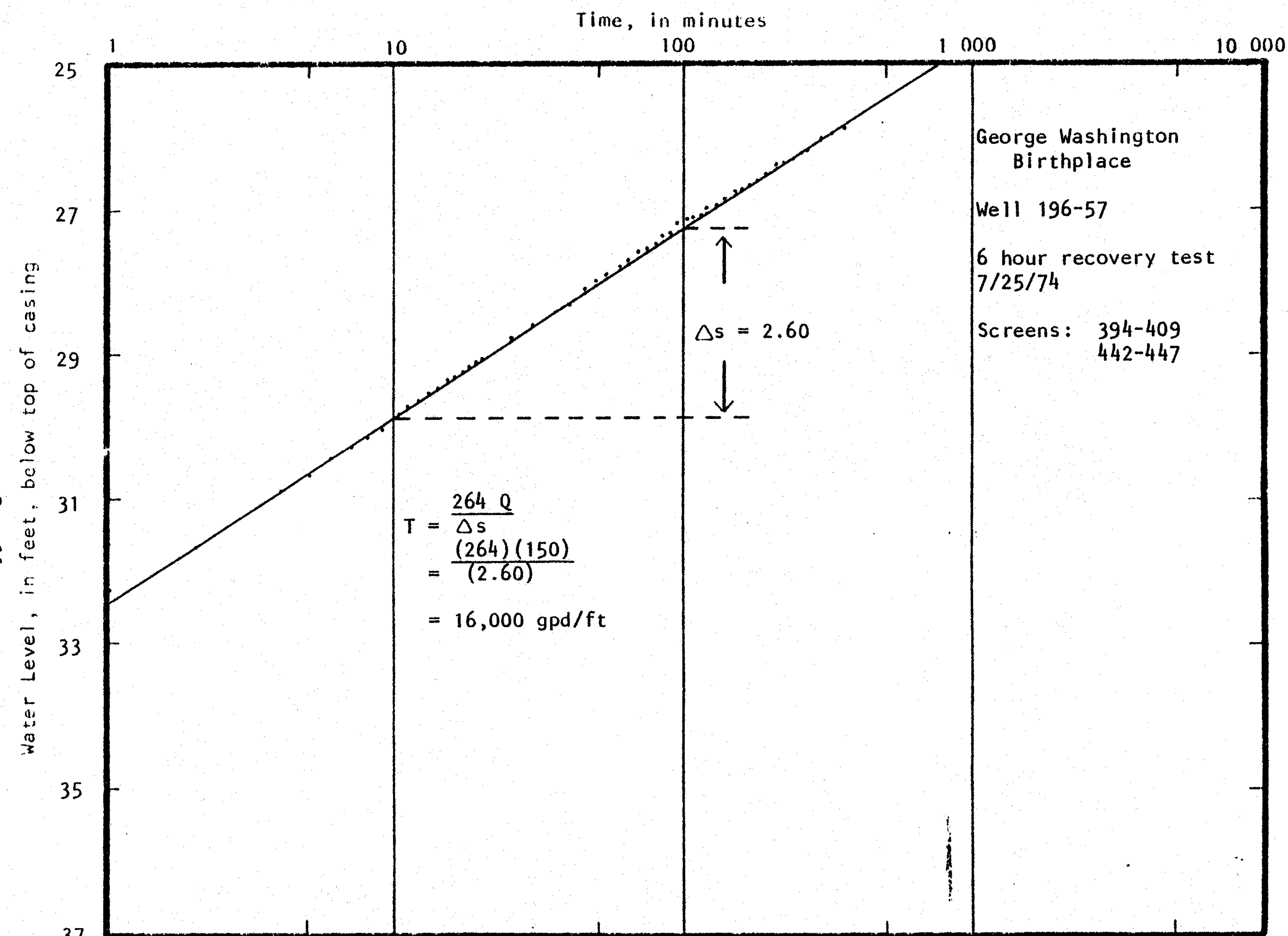
Source: State Water Control Board



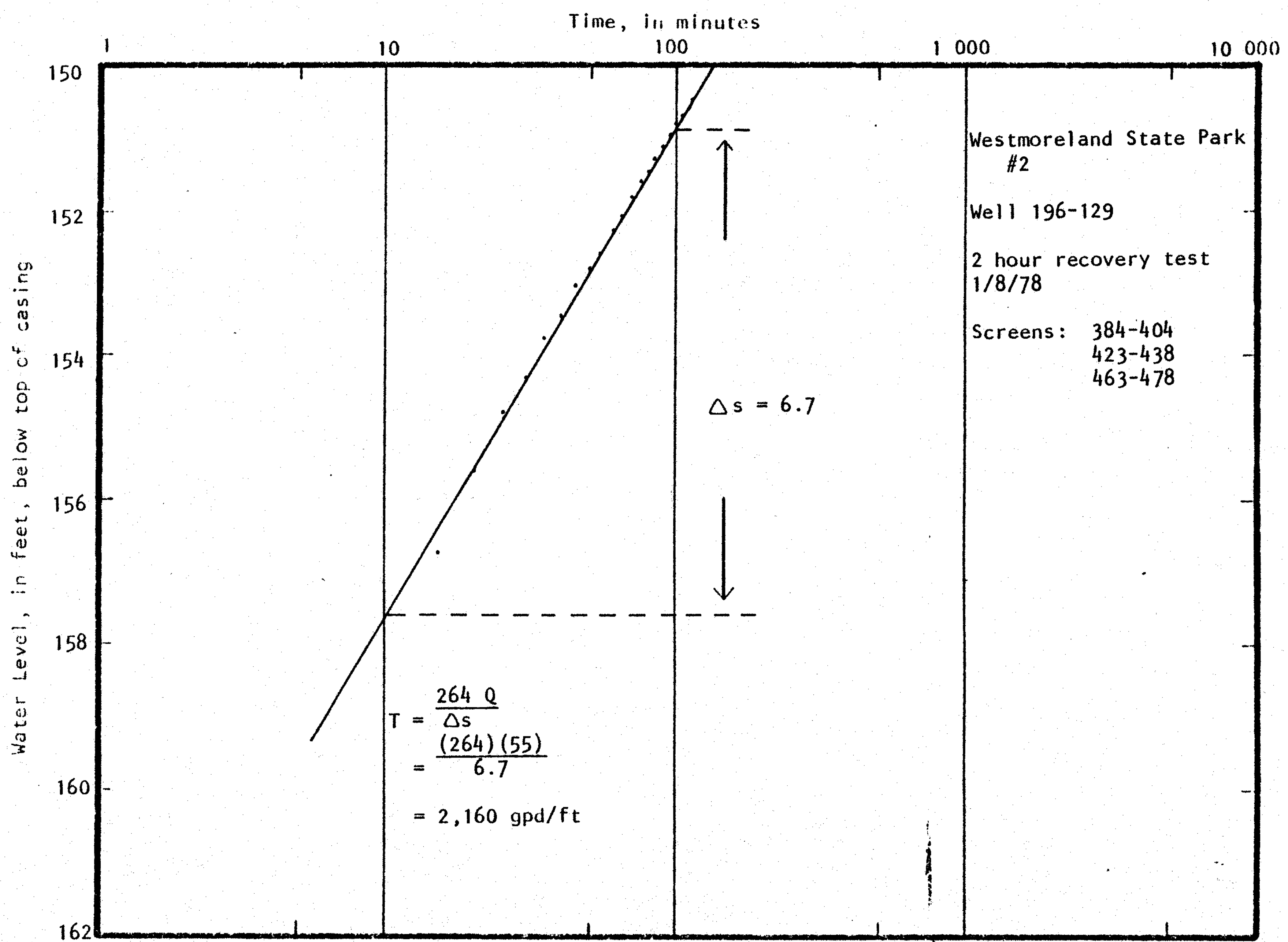
Source: State Water Control Board



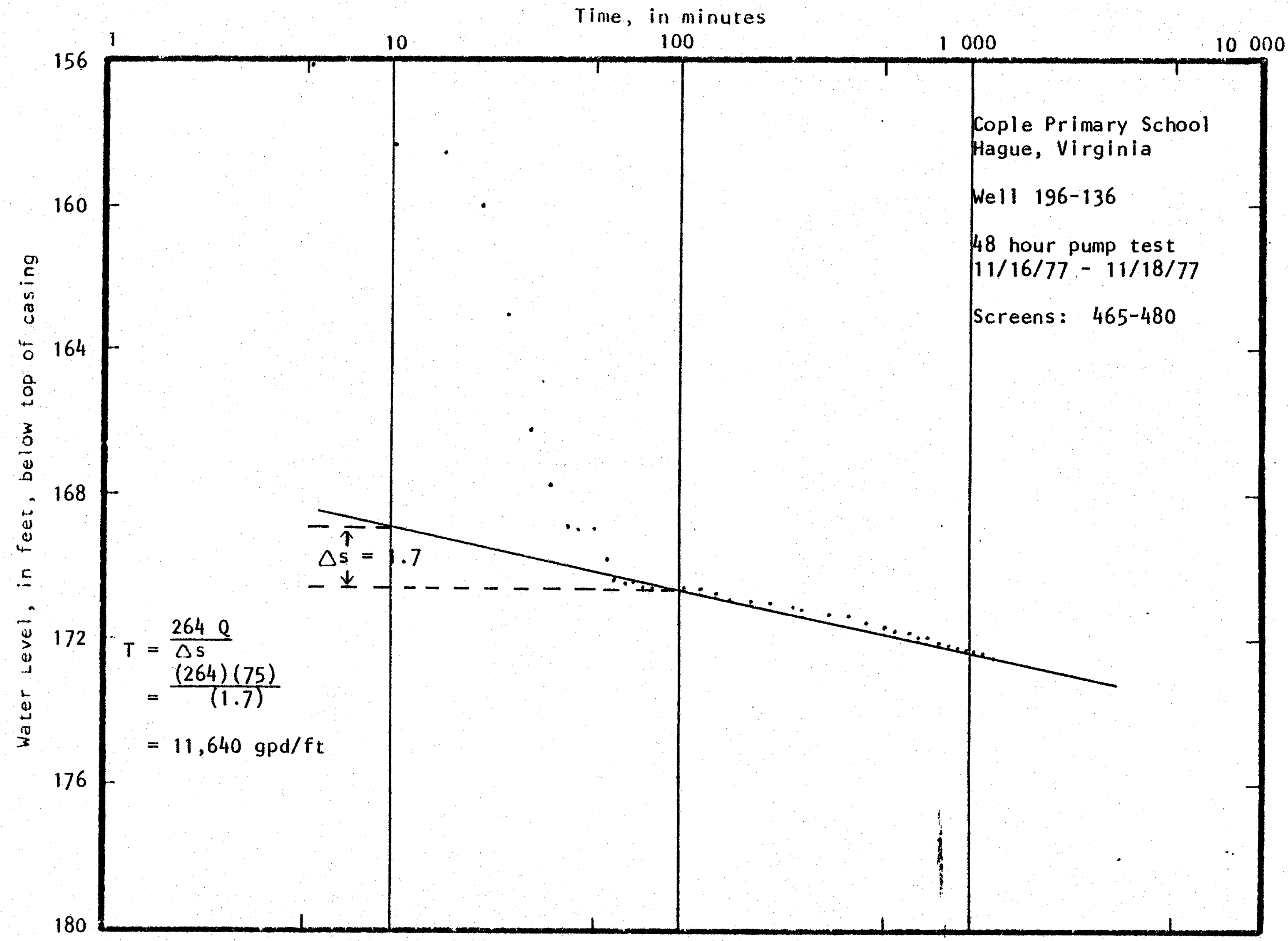
Source: State Water Control Board



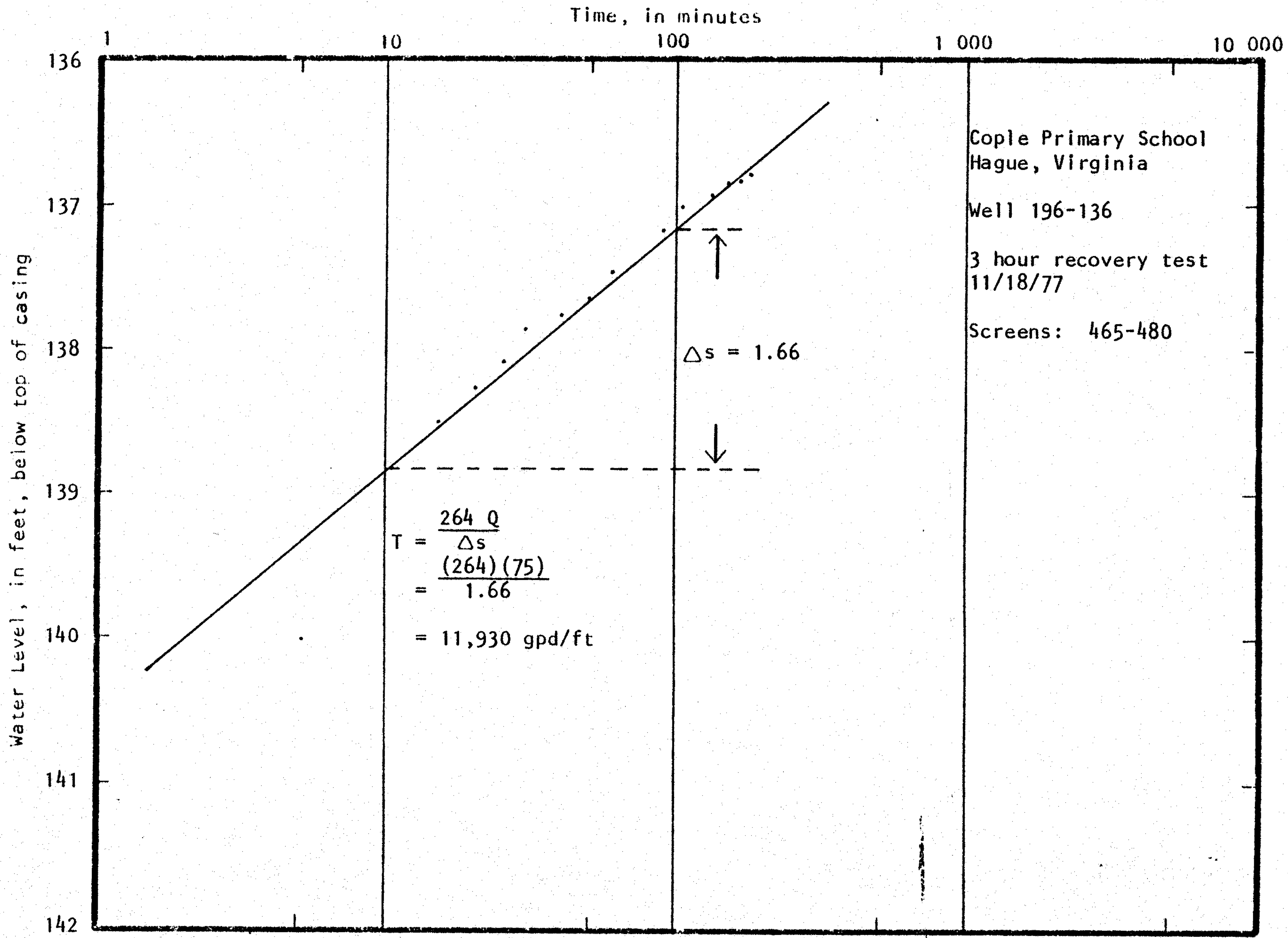
Source: State Water Control Board



Source: State Water Control Board



Source: State Water Control Board



Source: State Water Control Board

APPENDIX E

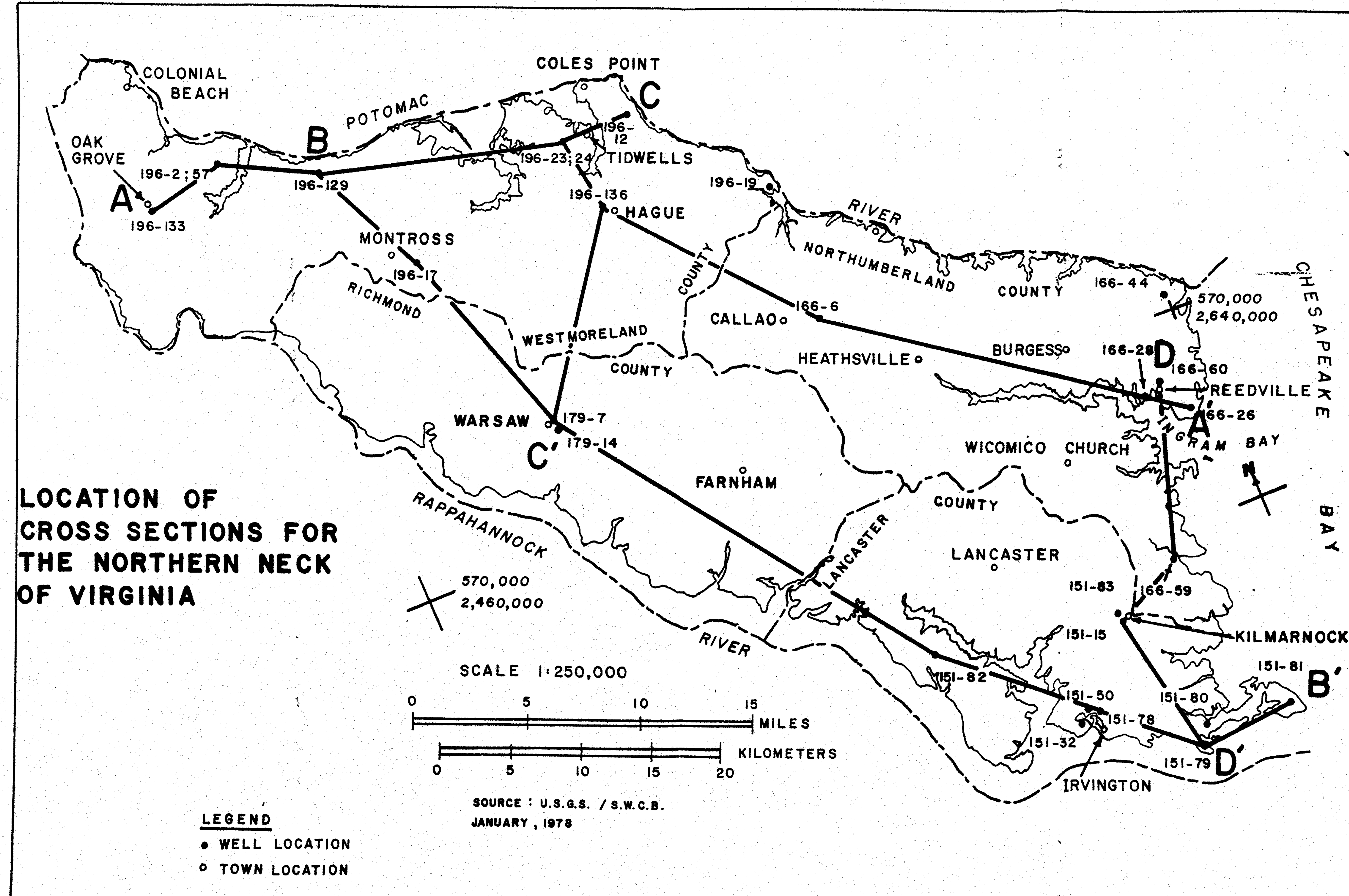
METRIC CONVERSIONS

ENGLISH	MULTIPLY BY	METRIC
Cubic Feet (ft^3)	2.832 X 10	Liters (L)
Cubic feet per minute (ft^3/min)	2.832 X 10	Liters per minute (L/min)
Degrees Fahrenheit (^oF)	(F^o-32) .556	Degrees Celsius (^oC)
Feet (ft)	3.048 X 10^{-1}	Meters (m)
Gallons (gal)	3.785	Liters (L)
Gallons per day per foot (gpd/ft)	1.242 X 10^{-1}	Liters per day per meter (L/day/m)
Gallons per minute (gpm)	3.785	Liters per minute (L/min)
Gallons per minute per foot (gpm/ft)	1.242 X 10^{-1}	Liters per minute per meter (L/min/m)
Inches (in)	2.540	Centimeters (cm)
Miles (mi.)	1.609	Kilometers (Km)
Ounces (oz.)	2.8349 X 10	Grams (g)
Pounds (lb.)	4.536 X 10^{-1}	Kilograms (Kg)
Square miles (mi^2)	2.590	Square kilometers (Km^2)
Tons (T)	9.0178 X 10^2	Kilograms (Kg)
Yards (Y)	9.144 X 10^{-1}	Meters (m)

APPENDIX F

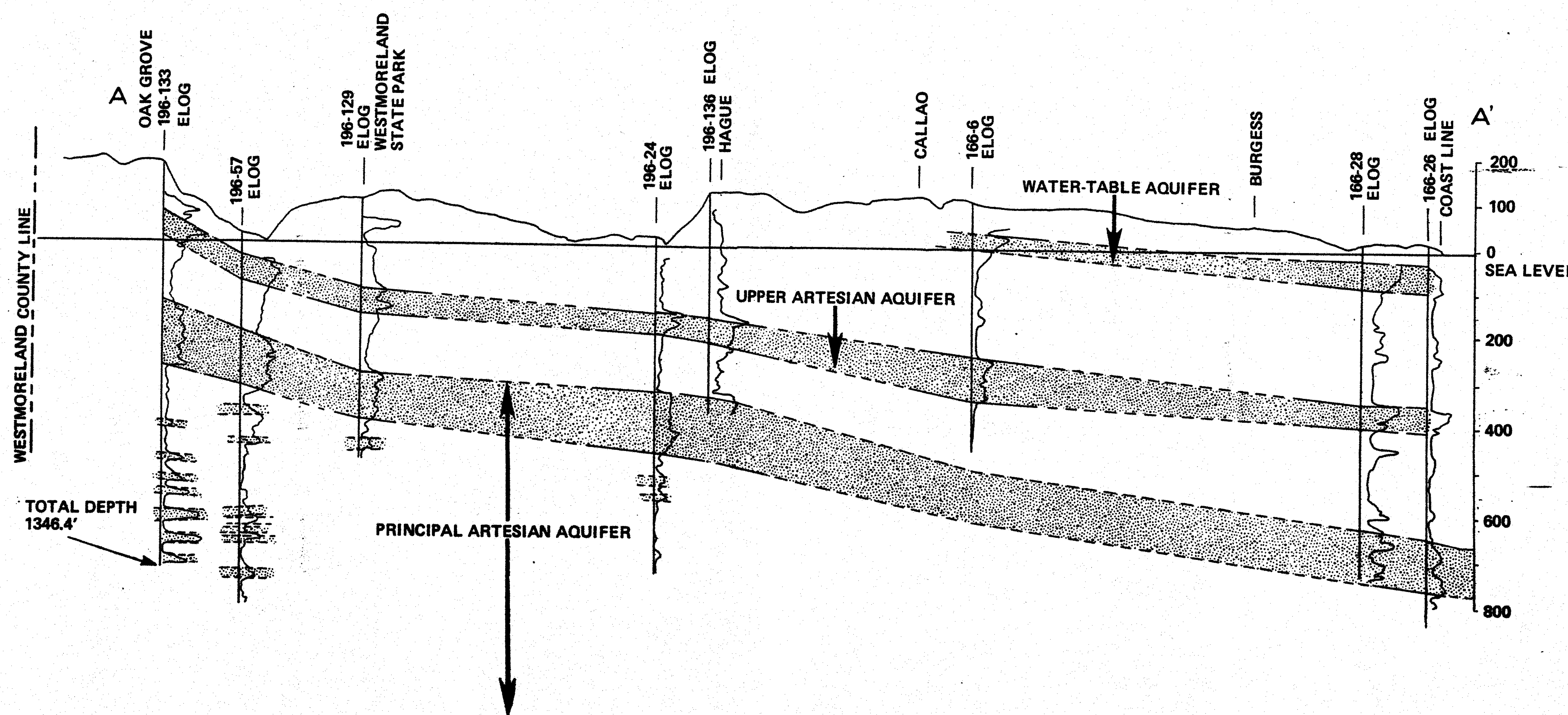
GEOPHYSICAL CROSS-SECTIONS

Appendix F consists of a series of four interconnected geophysical cross-sections. These are drawn from a combination of electric and gamma logs of various wells located in the Northern Neck. The location of the wells and of the lines of cross-section is plotted on the following map. Well numbers can be cross-referenced to Appendix A. The logs in Appendix F were run by the State Water Control Board, the U. S. Geological Survey and drilling contractors.

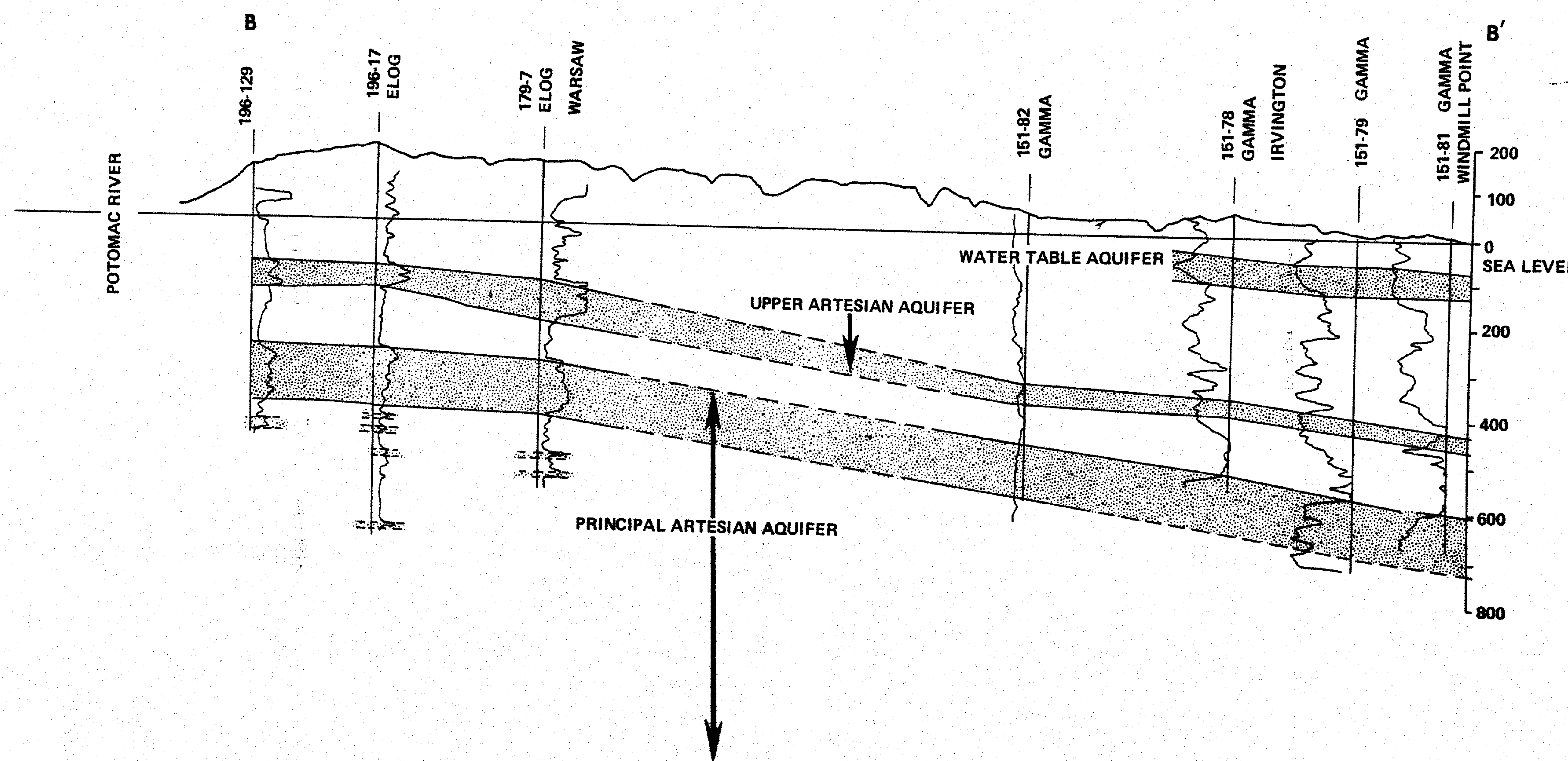


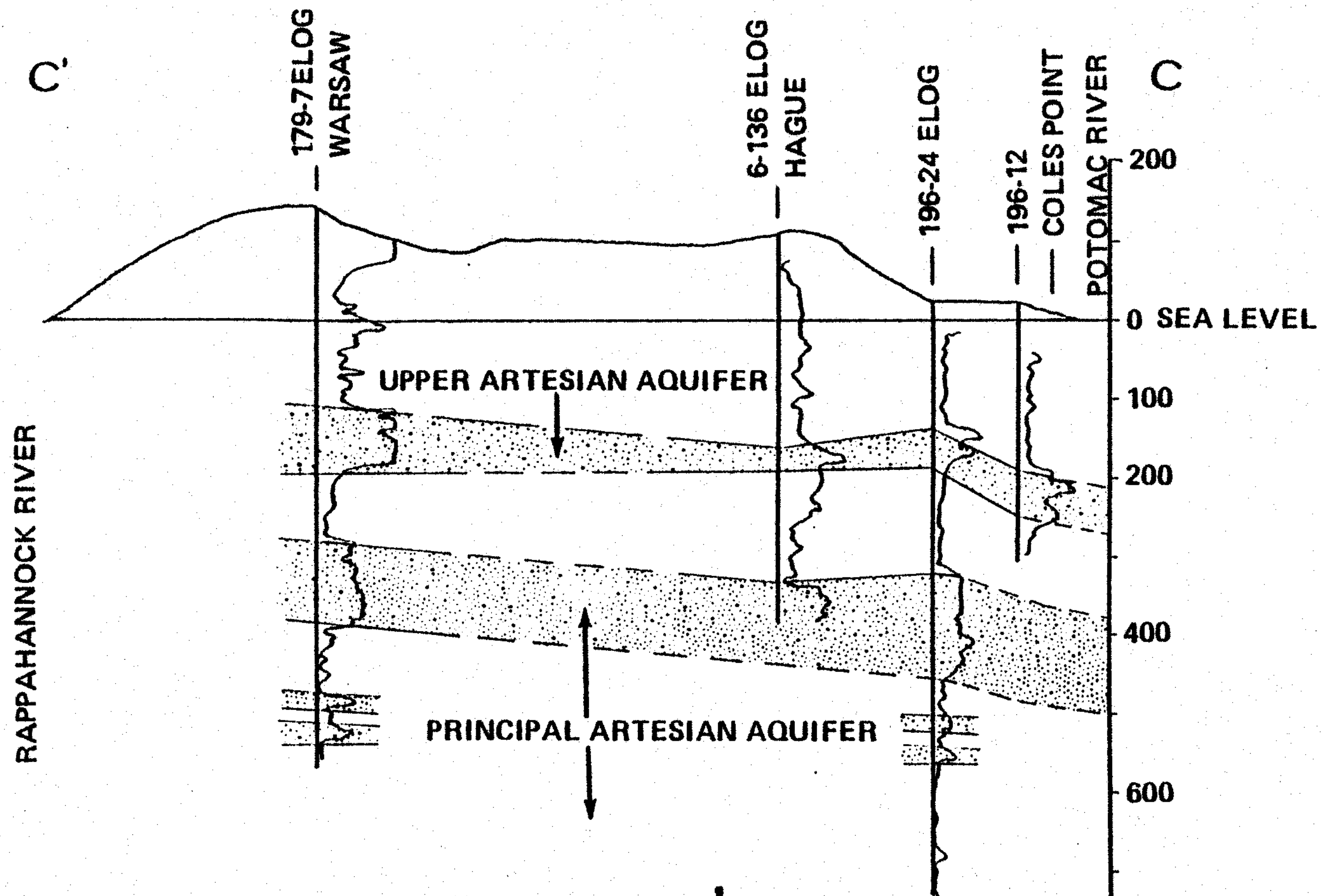
LOCATION OF CROSS SECTIONS FOR THE NORTHERN NECK OF VIRGINIA

CROSS SECTION A-A'
THE NORTHERN NECK OF VIRGINIA



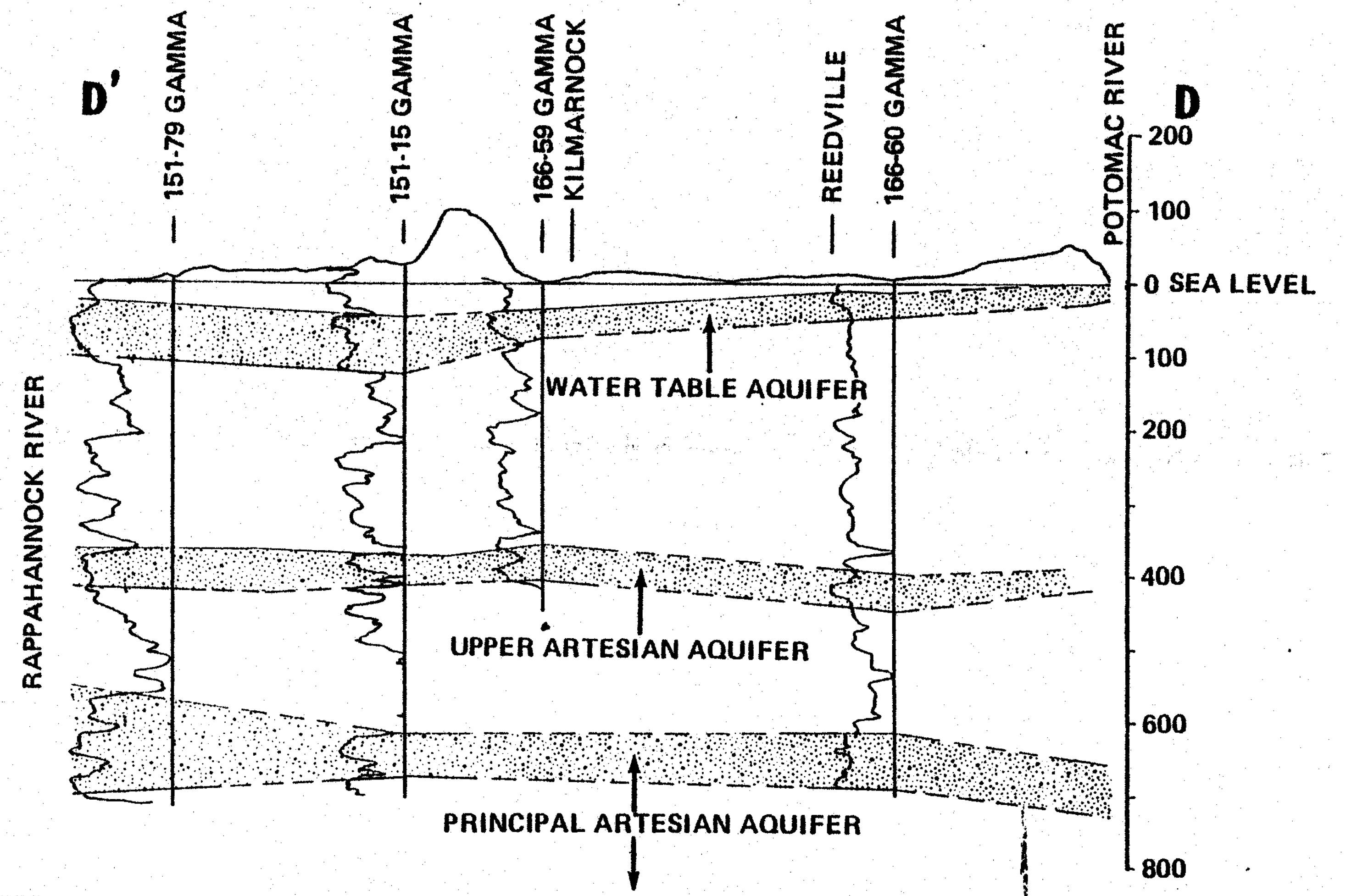
CROSS SECTION B-B′
THE NORTHERN NECK OF VIRGINIA





CROSS SECTION C'-C
THE NORTHERN NECK OF VIRGINIA

CROSS SECTION D-D'
THE NORTHERN NECK OF VIRGINIA



GLOSSARY

AQUICLUDE	A formation of relatively low permeability that overlies or underlies an artesian aquifer and confines water in the aquifer under pressure. It contains little or no water and transmits essentially none.
AQUIFER	A water-bearing formation, group of formations, or part of a formation that will yield groundwater in useful quantities.
AQUIFER SYSTEM	A group of inter-related aquifers.
AQUITARD	A formation that partially restricts groundwater flow. It contains water, transmits it slowly, but will not yield water to a well.
ARTESIAN AQUIFER	A confined aquifer in which groundwater rises in a well above the point at which it is found in the aquifer.
ARTESIAN WELL	A well in which the water rises under artesian pressure above the top of the aquifer (the well penetrates), but does not necessarily reach the land surface.
AUTOCHTHONOUS	A term applied to rocks of which the dominant constituents have been formed in the natural or original position as opposed to prior to erosion and disposition.
BEDROCK	Any solid rocks exposed at the surface or overlain by unconsolidated materials.
BICARBONATES (Metal + HCO_3 e.g. Na HCO_3)	Can raise the pH to a high concentration which may be corrosive.
CAPILLARY FRINGE	The zone of partial or complete saturation directly above the water table in which water is held in the pore spaces by capillarity.
CHLORIDES (Cl^-)	Are indicative of concentrations of salt water concentrations above 250 milligrams per liter (mg/l) are detectable by taste.

CLASTIC ROCK	A consolidated sedimentary rock composed of broken fragments that are derived from pre-existing rocks, e.g. sandstone, conglomerate, or shale, etc.
CONE OF DEPRESSION	A conelike depression of water table or of the peizometric surface that is created in the vicinity of a well by pumping. The surface area included in the cone is known as the area of influence of the well.
CONFINED WATER	Water under artesian pressure. Water that is not confined is said to be under water table conditions.
CONFINING BED	A bed which overlies or underlies an aquifer and which, because of low permeability relative to the aquifer, prevents or impedes upward or downward loss of water and pressure. An aquiclude.
CONSOLIDATED	A rock that is firm and rigid in nature due to the natural interlocking and/or cementation of its mineral grain components. The reverse is unconsolidated.
CROSS-SECTION	A diagram or drawing that shows features transected by a given plane; e.g. geologic feature such as geologic structure.
DIATOMACEOUS EARTH	An easily crumbled, earthy deposit consisting essentially of the shells of the microscopic plants called diatoms.
DISSOLVED SOLIDS	Generally noticeable in concentrations greater than 500 mg/l.
DRAWDOWN	The depression or decline of water level in a pumped well or in nearby wells caused by pumping. It is the vertical distance between the static and the pumping levels of the wells.
EVAPOTRANSPORATION	The process by which surface water, soils and plants release water vapor to the atmosphere.
FACIES	The rock record of different sedimentary environments as distinguished by both physical and organic characters, often lateral subdivisions.

FLOWING WELL	A well having sufficient artesian pressure head to discharge water above the land surface.
FLUVIAL-DELTAIC	Pertaining to rivers, streams, ponds, or river deltas.
FORMATION	A unit of geologic mapping consisting of some one kind of rock material. Also a unit having lateral or vertical continuity.
GLAUCONITE	A green mineral, closely related to the micas and essentially a hydrous potassium iron silicate. Commonly occurs in sediments of marine origin.
GREENSAND	A sand rich in glauconite grains.
GROUNDWATER	Water beneath land surface in the zone of saturation and below the water table.
HARDNESS	Quality of water that prevents lathering because of calcium and magnesium salts which form insoluble soaps.
HYDRAULIC GRADIENT	The gradient or slope of the water table of piezometric surface, in the direction of the greatest slope generally expressed in feet per mile.
HYDROGEOLOGY	The science of the natural laws that control occurrence and movement of groundwater. Geology as affected by hydrology.
HYDROLOGY	The science that relates to water movements and physical characteristics.
IGNEOUS ROCKS (Basement Rock)	Rocks formed by the cooling and crystallization of molten or partly molten material.
IMPERMEABLE	Having a texture which does not allow perceptible movement of water through rock.
INDURATED	Rendered hard.
INFILTRATION	The flow of water through the soil surface into the ground.
INTERSTICES	The opening or pore spaces in a soil or rock formation. In an aquifer, they are filled with water.

LITHOLOGY	The large scale physical characteristics of rocks/sediments.
METAMORPHIC ROCKS	Rocks altered from pre-existing rocks by changes in temperature, pressure, and chemical environment.
NITRATES (NO_3)	A salt or ester of nitrous acid (concentrations greater than 45 parts per million (ppm) can be toxic).
NONFLOWING ARTESIAN WELL	An artesian well in which the head is not sufficient to raise water to the land surface at the well site.
pH	The negative logarithm of the Hydrogen Ion activity--measured 1 through 14 with 7 being neutral, 1 being indicative of highest acidity and 14 indicative of highest alkalinity.
PALEONTOLOGY	The study of fossil animal and plant remains (to determine past environments).
PERCOLATION	Movement under hydrostatic pressure of water through the interstices of rocks or soils, except movement through large openings such as solution channels.
PERMEABILITY	The ability of a rock to transmit water per unit of cross-section.
PIEZOMETRIC SURFACE	An imaginary surface that everywhere coincides with the hydrostatic head of water in an artesian aquifer.
POROSITY	The ratio of the volume of the openings in a rock to the total volume of the rock.
PUBLIC SUPPLY	As defined by the Virginia Department of Health, a water system serging 25 individuals or more than 15 residential connections.
PUMPING LEVEL	Depth to water in a well when the well is being pumped.
RECHARGE	The addition of water to an aquifer by natural infiltration or artificial means. Injection of water into an aquifer through wells is one form of artificial recharge.
RECOVERY	The residual drawdown after pumping has stopped.

RUNOFF	That part of precipitation that flows in surface streams. Groundwater recharge is that part of runoff which has existed as groundwater since its last precipitation.
SALTWATER INTRUSION	The phenomenon occurring when a body of saltwater, because of its greater density, invades a body of freshwater. This may be caused by a loss of pressure in a freshwater aquifer.
SEDIMENT	Material borne and deposited by water.
SEDIMENTARY ROCKS	Usually stratified formations consisting of products of weathering by action ~~of~~ water, wind, ice, etc.
STATIC WATER LEVEL	The level of water in a non-pumping or non-flowing well.
STRATIGRAPHY	The relationship of the formation composition, sequence and correlation of layered rocks or sediments.
STORAGE COEFFICIENT	Volume of water contained in an aquifer which is related to porosity. Expressed as an absolute value normally from 0.00001 to 0.002 for artesian aquifers and from 0.02 to 0.35 for water table conditions.
TERRACE DEPOSITS	Deposits of alluvium (sand, gravel, cobble or clay) which occurs along the margin and above the level of a body of water, marking a former water level.
TOPOGRAPHY	The relief and form of a land surface.
TRANSMISSIVITY	The capacity of an aquifer to transmit water in gallons per unit of time per section 1 foot wide by aquifer thickness. Expressed as gallons per day per foot (gpd/ft) normally ranging from 1000 to 1,000,000 gpd/ft.
UNCONFINED AQUIFER	Water not under artesian pressure. Generally applied to denote water below the water table.
UNCONSOLIDATED	A sediment that is loosely arranged or unstratified, or whose particles are not cemented together.

WATER TABLE	The upper, unconfined surface of the zone of saturation. The surface in water table aquifer at which the water level stands.
WATER-TABLE AQUIFER	An aquifer which is not confined above, in which the water level in a well indicates the water table.
WATER WELL	An artificial excavation (pit, hole, tunnel) generally cylindrical in form and often walled in, sunk (drilled, dug, driver, bored, jetted) into the ground to such a depth as to penetrate water-yielding rock and to allow water to flow or to be pumped to the surface
ZONE OF AERATION	The zone in which the open spaces in soil or in a rock formation contain air and water.
ZONE OF SATURATION	The zone in which the open spaces in the rocks are completely filled with water.

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